POWER PLANT ENGINEERING

Established Over 34 Years

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Out of the Past, Into the Future

IN 1796 COL. GEORGE NEWCOM left Cincinnati and traveled north, 60 mi. through Hamilton, to Dayton. Here he built a one-room cabin which in the winter of 1798-1799 gave place to a palatial tavern of two stories and four rooms, destined to become the hub of the Miami valley section and Dayton's first tavern, school, church, store, courthouse and jail.

It represented advanced ideas in building and its hewn logs chinked with mortar offered a striking contrast to the current round log cabins daubed with clay. People from up country went home and told admiring neighbors about Newcom's. Lime used was the first made in Dayton. A huge log fire took the place of a kiln and on this fire was thrown limestone gathered from the river bed. A country boy told his family Col. Newcom had plastered his house with flour.

In the century and a third following the construction of the tavern, thousands of buildings were built, buildings which may have been and probably were more comfortable and undoubtedly better looking yet there is no reason for preserving them—their numbers hide any individual characteristics.

So it is with power plants; the early efforts of Watt are of interest not because of their usefulness in themselves but because of the influence they exerted on future industrial development. Thousands of power plants now in existence are of no more value or interest than the thousands of midwestern log cabins. In the modern industrial scheme they are of less value than fireplaces and much less decorative. Transforming these antiques into modern plants is not easy but it can be done. Turn to the next page and see what one plant, not so many miles from Newcom's historic tavern, has done. Its designer has accomplished something unique and has done as much for industrial development as Col. Newcom did for residential development almost a century and a half ago.

The Champion Coated Paper Co. *builds an* Outstanding Power Plant

Record breaking single 20,000 kw., 600-lb. triple element turbine and 2719 hp. boiler in Hamilton, O., power plant serves 500 ton per day paper mill at no sacrifice of flexibility or reliability. Plant, which cost about $55 per kw. of capacity, has many distinctive features which place it far ahead of contemporary industrial practice. Largest plant in the world to be served by a single boiler and single turbine unit.

ADVANTAGES OF LOWER first cost, higher efficiency and improved operation of large steam and electric generating units have long been recognized and, to a certain extent, taken advantage of in central station practice where the use of a single large boiler serving a single generating unit, although not common, has been used. Yet it has remained for an industrial plant, the Champion Coated Paper Co. of Hamilton, O., to carry the idea to the logical conclusion; an industrial plant served with steam and electric power by a single large boiler and turbine unit. In addition to being the largest factory in the world run by one boiler and one turbine, the boiler is the largest unit fired pulverized coal boiler as well as the largest high-pressure boiler yet built.

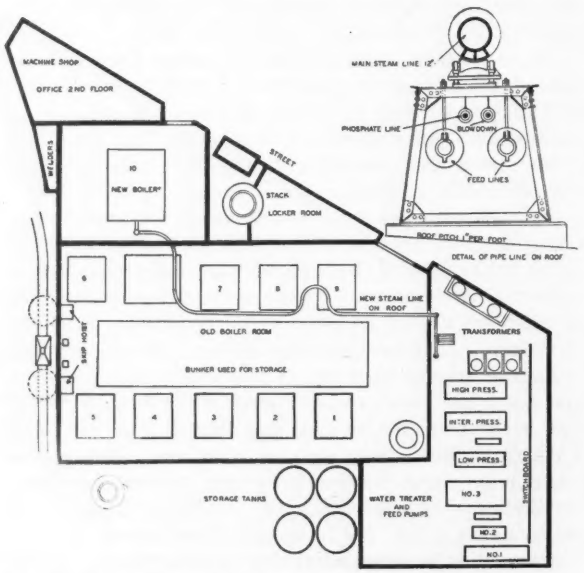


FIG. 1. PLAN OF POWER STATION AND DETAILS OF THE STEAM LINE SUPPORTS

To accomplish this without sacrificing reliability and flexibility of operation was no mean task. It has been accomplished in a most successful manner, however, by a plant that sets the high water mark in industrial power plant design, a plant which, although built of tried and proven equipment, contains combinations of equipment and incorporates refinements of design that are as individual as the man responsible for the design and construction. This man is Guy B. Randall, superintendent of power, perhaps best known to the power plant field for his accomplishments while superintendent of power at the National Cash Register Co. at Dayton, Ohio, particularly in connection with his early work on pulverized coal.

Briefly, the new plant, built at a cost of about $55 per kw. of capacity, consists of a 600-lb., 750-deg. F., 20,000-kw. triple element turbine and a 650-lb., 750-deg. F. pulverized coal fired boiler with a maximum steaming capacity of 343,000 lb. per hr. The boiler is of the 3 pass Babcock & Wilcox, longitudinal drum type with a heating surface of 27,192 sq. ft., a 5300 sq. ft. interdeck superheater, a 47,742 sq. ft. tubular air heater, 2620 sq. ft. of Bailey water-cooled walls and a furnace volume of 19,080 cu. ft. The unit is fired by four 10,000 lb. per hr. Riley duplex pulverizers with an overall boiler efficiency of 86 to 87 per cent. This is the largest high-pressure boiler unit in industrial service and actually the largest unit fired installation in the world. The pulverized coal burners are the largest ever built, one burner having successfully burned 12,000 lb. of coal per hour.

The turbine is a triple element machine consisting of new General Electric high and intermediate-pressure elements and an existing Westinghouse low-pressure element. The high pressure turbine takes 600-lb. ga.

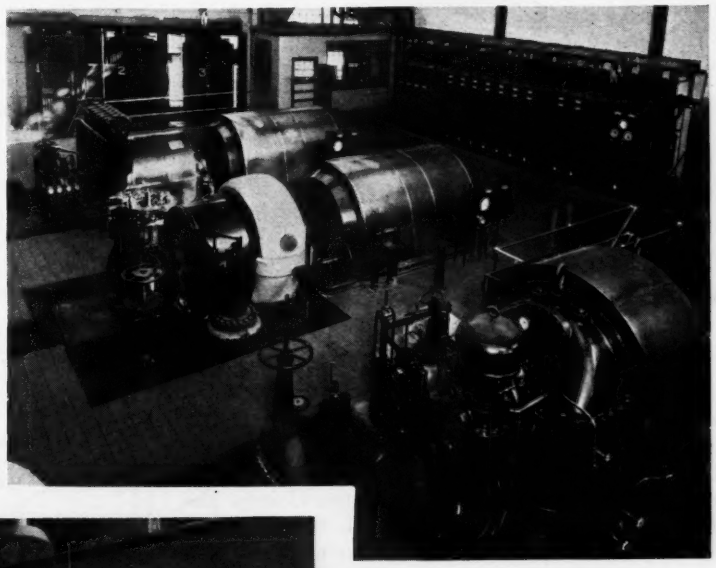


FIG. 2. ELECTRIC POWER IS FURNISHED BY A SINGLE 20,000-KW. TRIPLE ELEMENT TURBINE

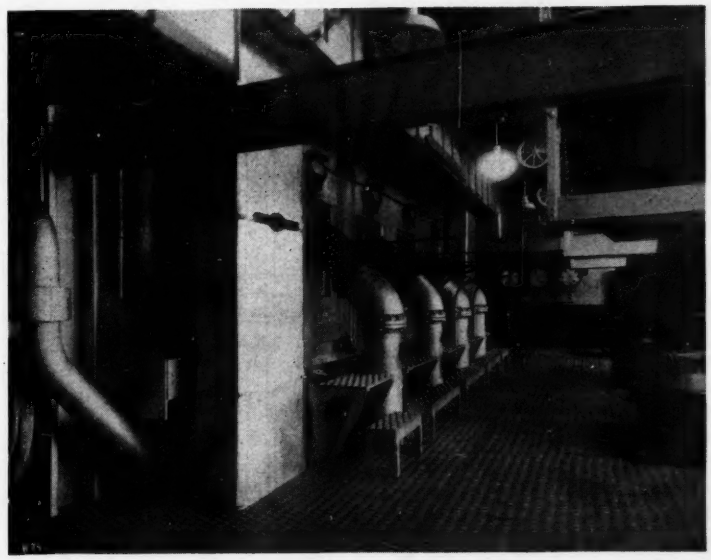


FIG. 3. STEAM IS SUPPLIED AT 650 LB. BY A SINGLE 2719-HP. PULVERIZED COAL-FIRED BOILER, THE LARGEST KNOWN UNIT FIRED PULVERIZED FEED UNIT IN THE WORLD

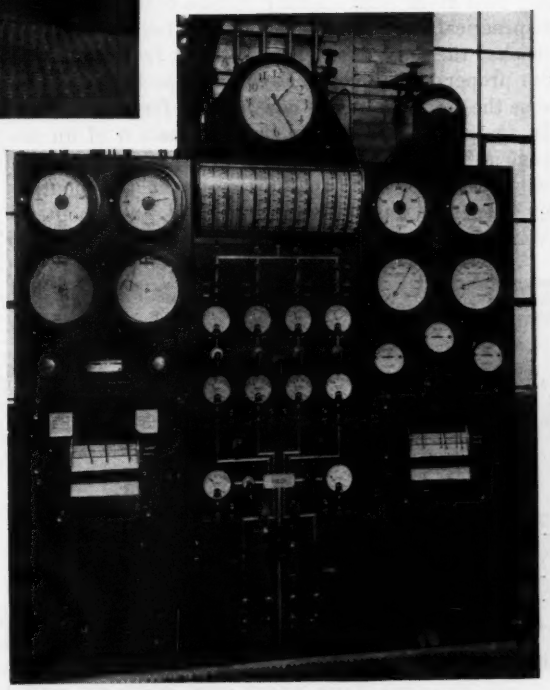


FIG. 4. BOILER OPERATION IS CONTROLLED FROM THIS PANEL

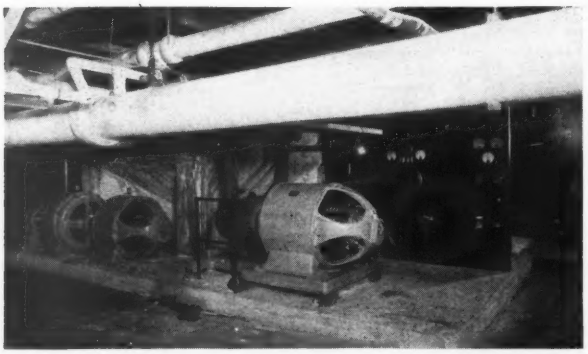


FIG. 5. ONE OF THE VARIABLE SPEED PAPER MACHINE DRIVES COMPLETE WITH CONTROL PANEL AND MOTOR GENERATOR SET

steam and exhausts, at 175 lb. ga., to the intermediate pressure element and to the 175-lb. ga. process line; the intermediate element, bled at 90 lb. ga. for feed heating, exhausts at 15 lb. ga. to the low-pressure element and to the 15 lb. process main while the low-pressure element operates condensing. In the summer, the low-pressure element never carries more than 5 per cent of the total electric power. In the winter when the heating load is on, the third or low-pressure turbine element is not needed for balance, so that the average condensing power for the year is about 2 to 3 per cent of the total as compared to about 75 per cent two years ago. The first two elements drive 9375-kv-a., 2300-v. generators, the third a 1875-kv-a., 440-v. generator. The power factor of the plant ranges around 95 per cent so that the total rating of 20,625 kv-a. represents practically 20,000 kw.

Standby or emergency service is taken care of by the old equipment, which was brought up to peak performance and put in good shape before the new plant was built. This gives ideal standby service because it represents practically no investment, having been written off the books; the only fixed charges being from the value of the property occupied. Even this has been reduced because the old bunkers are now utilized for coal storage.

In fact, the new plant is the culmination of an improvement program extending over a period of almost three years, going back to the time when the monthly boiler efficiency was below 70 per cent and about 75 per cent of the electric power used, including from 1500 to 2000 kw. purchased, was from condensing turbines. Paper machines were driven by steam engines. Steam was supplied by nine 800-hp., 200-lb. and one 1330-hp. underfeed stoker fired boilers and electric power by four turbines totaling 14,375 kv-a. consisting of: No. 1, 2500 kv-a., 175 lb. noncondensing; No. 2, 2500 kv-a., 175 lb., noncondensing; No. 3, 7500 kv-a., 175 lb., condensing (10,000-sq. ft. Elliott condenser) and No. 4, 1875 kv-a., 15 lb., condensing (3000-sq. ft. C. H. Wheeler condenser). In order to conform to the maximum pressure of the one large boiler, four of the smaller 200-lb. boilers, on one side of the firing aisle, were operated at 160 lb. Steam was distributed at both 160 and 200 lb. pressure.

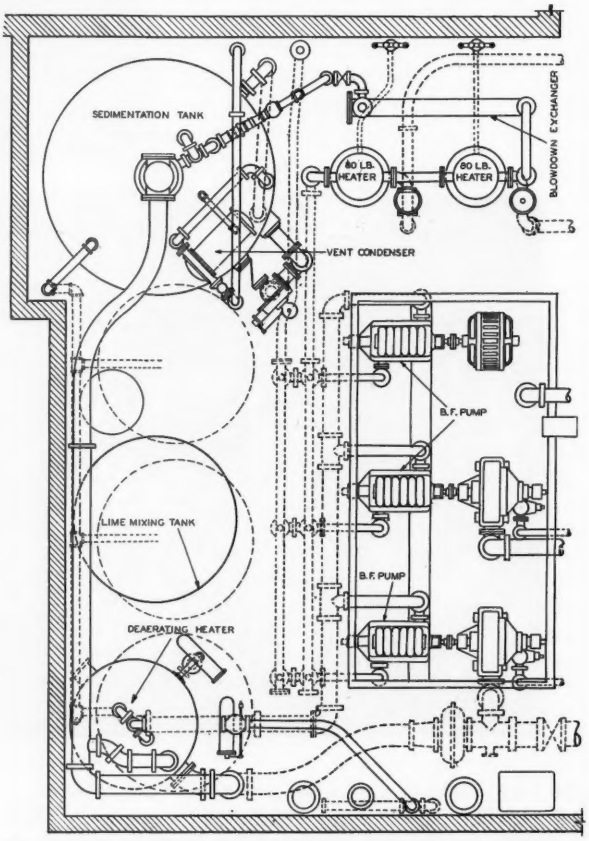


FIG. 7. PLAN OF PUMP ROOM SHOWING ARRANGEMENT OF PUMPS, HEATERS AND WATER TREATMENT EQUIPMENT

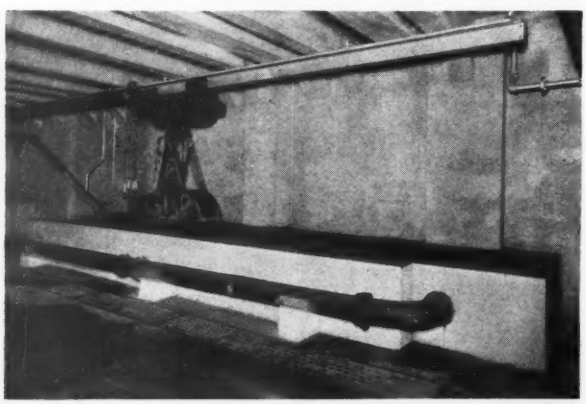


FIG. 6. FLY ASH FROM THE STACK SPRAY IS SLUICED DOWN TO THIS TANK

In the betterment program, one step was to improve firing conditions and stoker operation and increase the pressure to 200 lb. by cutting out the 160-lb. boiler; a second step was to improve turbine operation by reducing air leaks and increasing the circulating water so that purchased power could be cut down to the contract minimum, or 1000 kw.; a third step was to improve engine performance by proper valve setting. The practice has been to throttle the steam and set the valves so that cutoff came near the end of the stroke. In other words, the engines were taking steam practically the entire stroke. This program alone resulted in saving around over $50,000 a year. Overall boiler efficiency was increased from 70 to 75 per cent.

Electrification of the paper machines was also started and a total of 24 steam engines have been replaced by

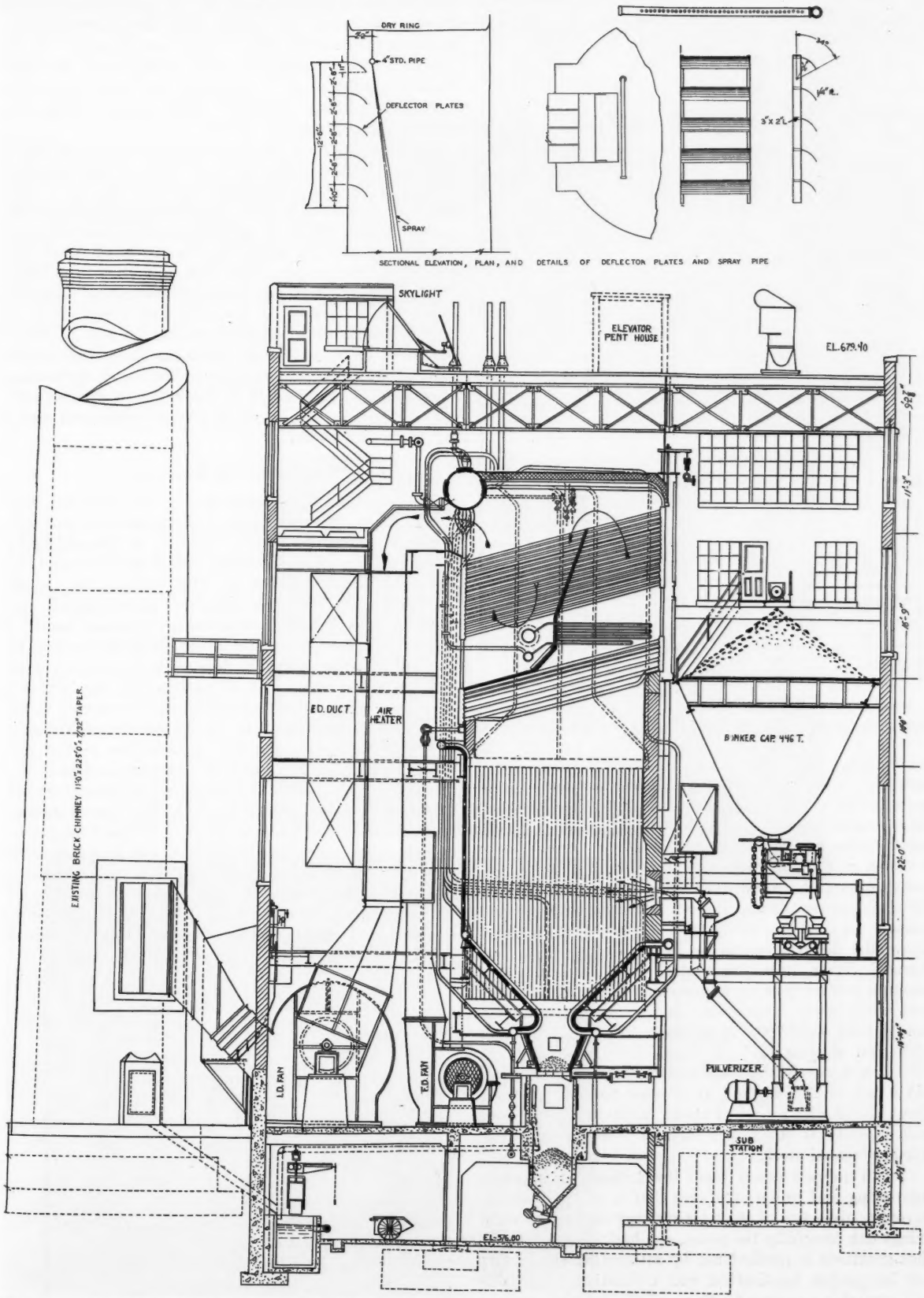


FIG. 8. AT MAXIMUM CAPACITY THIS 2719-HP. BOILER FIRED BY FOUR UNIT MILLS WILL DELIVER APPROXIMATELY 350,000 LB. OF 650-LB., 750-DEG. STEAM

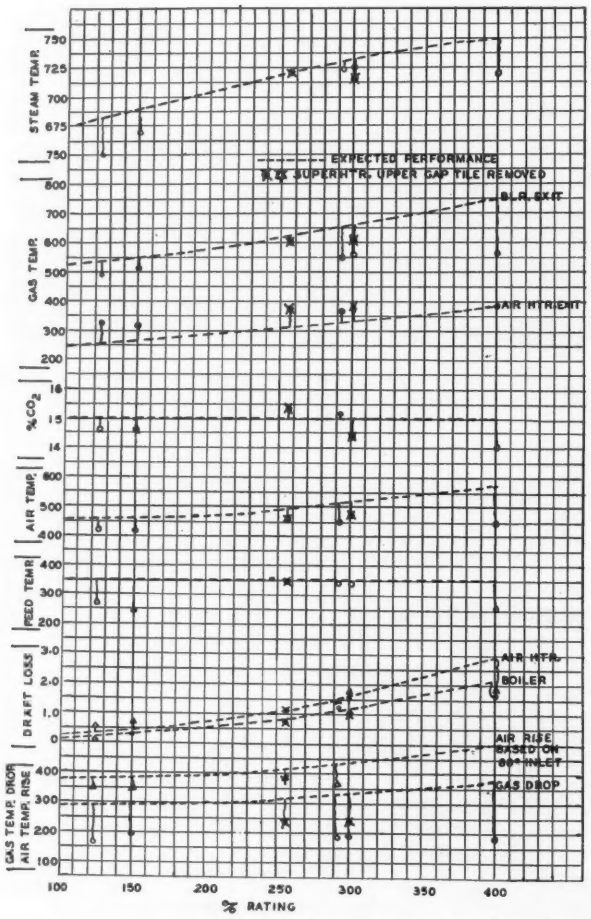


FIG. 9. EXPECTED PERFORMANCE OF THE BOILER UNIT

motors, many of them of the unity power factor synchronous type. This includes 11 paper machine drives; one sectionalized motor drive which was in before the power plant program was started and 10 Westinghouse variable speed drives which were installed later. One of these is shown in Fig. 5. It consists of a 265-hp., 2200-v. a.c. unity power factor synchronous motor driving a 175-kw., 250-v. d.c. generator and 7.5-kw., 230-v. direct connected exciter. A 220-hp., 250-v. d.c. variable speed motor drives the paper machine by belt. The speed can be changed either from the control board or the paper machine control desk in increments of less than ½ per cent while speed fluctuations due to voltage and load can be held within the same limit. The electrification added an electric load of about 1000 kw. mostly in 2300-v. motors, although some of the smaller motors are 440 v. a.c. or 220 v. d.c. At present the load averages about 13,500 with a peak of about 14,500 kw. The paper mill capacity is 500 t. per day, of which nearly two-thirds is coated stock.

As to the new power plant itself, there are so many interesting and unique features that it will be possible to cover only a few of the most striking ones. The plant brings out forcefully the point, emphasized many times, that greatness is reached not by attempting the bizarre but by proper application and utilization of reliable and available equipment. Some of the features covered in the following paragraphs include: firing floor, feeder and pulverizer arrangement; forced and induced draft fans on main floor with motor controllers directly above on firing floor; boiler control panel; stack sprays for fly ash and soot elimination; coal storage and handling facilities; boiler room arrangement, feedwater treatment, heating and pumps; turbine arrangement, piping and provision for emergency service.

A general plan of the development is shown in Fig. 1. The new boiler is located just off the northeast corner of the old boiler room in space formerly used as a coal storage. The new turbine is in the east end of the turbine room, which in addition to the three elements of the new turbine, houses the No. 1, No. 2, No. 3 and No. 4 turbines, which were left undisturbed. Boiler feed pumps, water treating tank, filter and heat exchangers are located as indicated just north of No. 1 turbine and as shown in greater detail in Fig. 7. From the boiler room the 650 lb. steam line is carried on the roof by the supports as shown in the upper right-hand corner of Fig. 1. This 12-in. steam line is covered with 1½-in. fire felt, 2½ in. of 85 per cent magnesia and 4 ply of roofing paper.

Coal and Ash Handling

As the new plant occupies the only available coal storage area, other provision for coal storage was necessary so the 3800-t. bunker capacity in the old boiler room was utilized by installing two 16-in. screw reclaiming conveyors underneath it. This bunker is of the old flat bottom concrete type admirably suited to this purpose. A diagrammatic arrangement of the coal handling system and interlock arrangements are shown by Fig. 10.

Coal received by rail is dumped into a track hopper and feeds, either through or past a ring crusher, to a bucket elevator which elevates it and discharges either to a belt for distribution to the old storage bunker or to a 16-in. screw conveyor for distribution to the new bunker. Coal for storage is not finely crushed as it may be used in the stokers of the old plant. In normal service, therefore, coal reclaimed from the bunker passes through the crusher before being elevated to the new bunker although in an emergency the crusher can be bypassed as shown by the sequence diagram of Fig. 10. Because of the higher efficiency of the new plant, the new bunker storage capacity of 446 t. plus 3800 t. of the old, gives a total coal storage capacity, measured in days, considerably in excess of what it was with the old plant.

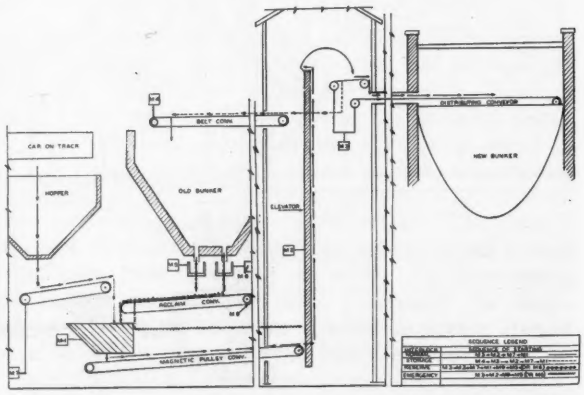


FIG. 10. DIAGRAMMATIC ARRANGEMENT OF THE COAL HANDLING AND RECLAIMING EQUIPMENT

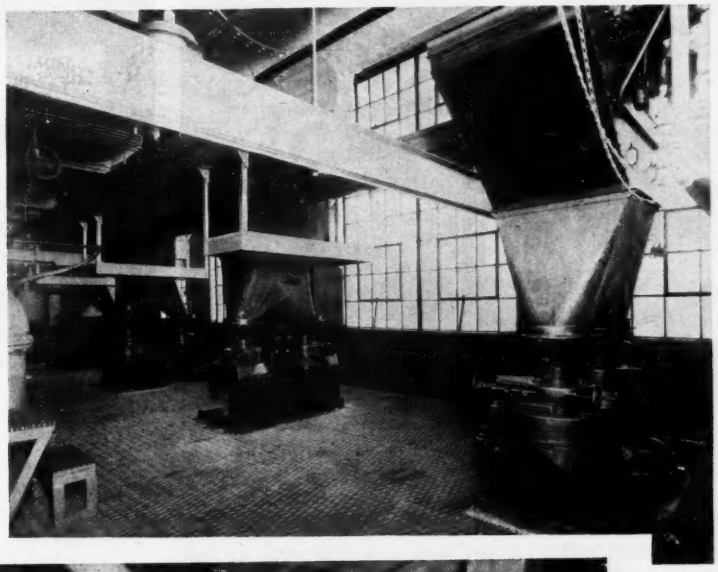


FIG. 11. EACH PULVERIZER IS FED BY TWO VARIABLE SPEED DUPLEX FEEDERS

FIG. 12. PULVERIZERS ARE PLACED ON THE MAIN FLOOR BELOW THE FEEDERS

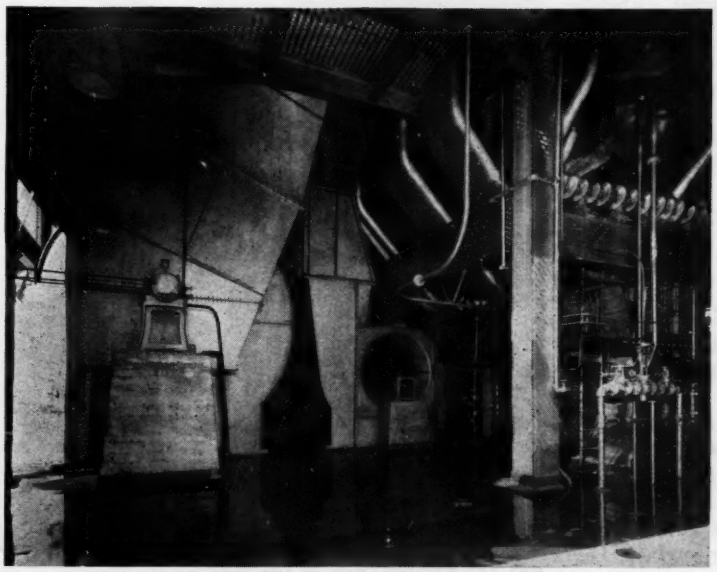


FIG. 13. BOTH FORCED AND INDUCED DRAFT FANS ARE LOCATED ON THE MAIN FLOOR

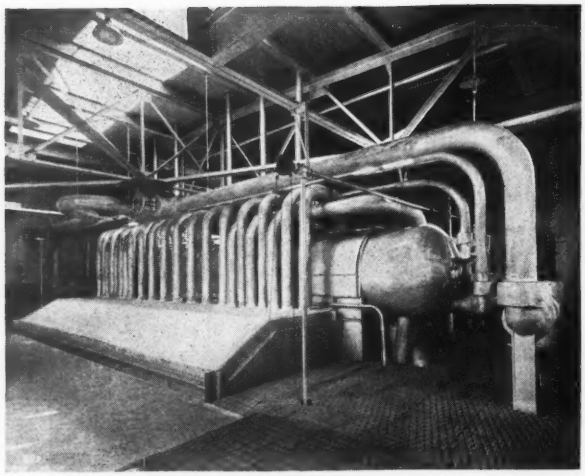


FIG. 14. TOP FLOOR SHOWING THE TOP OF THE AIR HEATER, BOILER DRUM AND FEEDWATER REGULATORS

Coal from the eastern Kentucky field running about 35 per cent volatile, 7.1 per cent ash and with an ash fusion temperature of about 2600 deg. F. is used. The ultimate analysis as received is as follows: Carbon, 76.85; hydrogen, 5.33; oxygen, 8.20; nitrogen, 1.50; ash, 7.15; and sulphur, 0.97.

Samples are taken each day at a specified time from 16 positions across two diameters of the coal pipe just preceding the burner. These sampling plugs can be seen in Fig. 3 just above the top step. As fired the coal runs about 70 to 75 per cent through 200 mesh, 2½ per cent moisture and a calorific value of about 13,800 B.t.u. per lb.

Boiler Room

The boiler house itself, with five floors and basement, measures 55 ft. wide, 71 ft. long and 98 ft. 9 in. high from the basement floor to roof slab. The gross inside area is 3905 sq. ft. and the inside volume 385,618 cu. ft. A cross section of the plant and boiler is shown in Fig. 8. Although compactly arranged, there is plenty of room and a crowded appearance has been avoided. This is particularly noticeable under the boiler on the main floor. As can be seen in Fig. 13, 16-in. solid sections have been used for the boiler supports instead of a 36-in. built-up section which would ordinarily be used for this size boiler. The boiler is of Babcock & Wilcox cross drum type with 54 in. dia., inside calked drum, 38 ft. 1 in. long. The total heating surface of 27,192 sq. ft. is made up of 4-in. tubes 24 ft. long arranged 45 sections wide and 22 tubes high. Alternate tubes in the bottom row are bent to form a slag screen and the boiler is baffled for 3 passes.

A 5300-sq. ft. convection superheater is between the fifth and sixth rows and a 47,742-sq. ft. tubular air heater with a downward gas flow behind the boiler, immediately above the induced draft fan. The furnace with a volume of 19,080 cu. ft. has a total of 2620 sq. ft. of Bailey water-cooled walls in three sides and bottom. Considering the boiler surface as 100 per cent, the relative values of other parts in per cent are: water walls, 10; superheater, 20; air heater, 175. The furnace volume is 0.54 cu. ft. per sq. ft. of heating surface, i.e., boiler proper plus superheater and water walls, and has

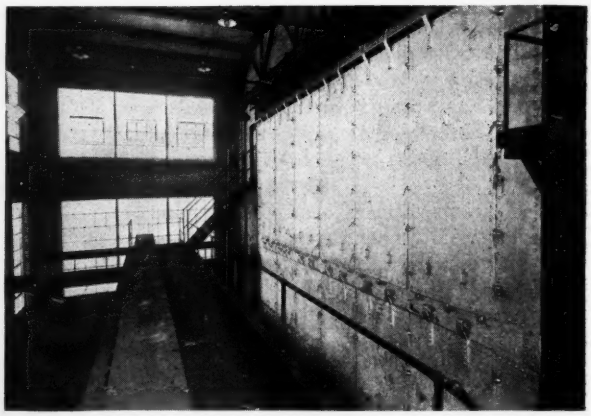


FIG. 15. THE COAL CONVEYOR IS OPPOSITE THE SUPERHEATER TUBES SO AS NOT TO INTERFERE WITH THE REMOVAL OF BOILER TUBES

a heat liberation about 23,000 B.t.u. per cu. ft. at 400 per cent rating.

At 400 per cent rating (350 deg. F. feed temperature) the maximum for which the unit was designed, the output will be 343,000 lb. of 625 lb. ga., 750 deg. F. steam per hour. Four Riley No. 4 duplex pulverizers, each with its exhauster discharging to an individual Riley No. 5 special burner are used. Based on coal with a grindability of 65, relative to Pocahontas as 100, each mill has an actual capacity of well over 10,000 lb. per hr. and each burner, with 575 deg. F. secondary air, a maximum capacity of 150,000,000 B.t.u. per hour. Each burner handles 10,000 lb. of coal per hr. nicely, in fact

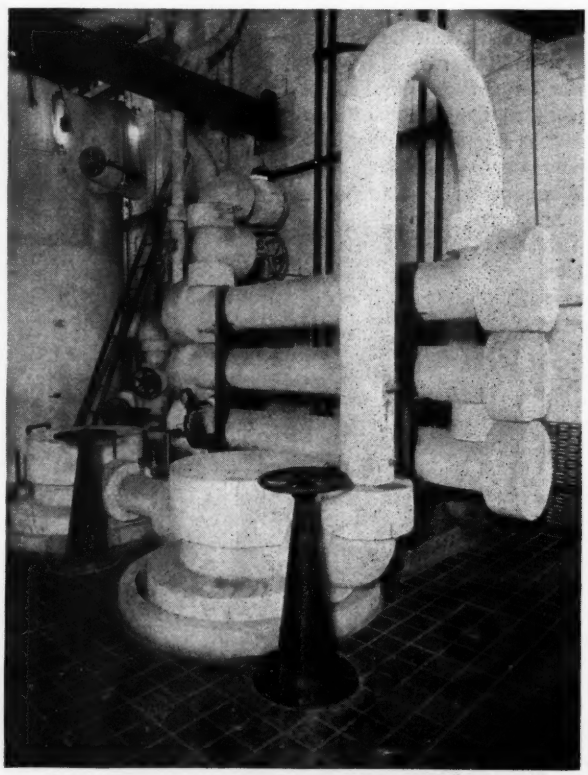


FIG. 16. FEEDWATER IS HEATED TO 350 DEG. F. BY TWO EXTRACTION AND ONE CONTINUOUS BLOWDOWN HEATER

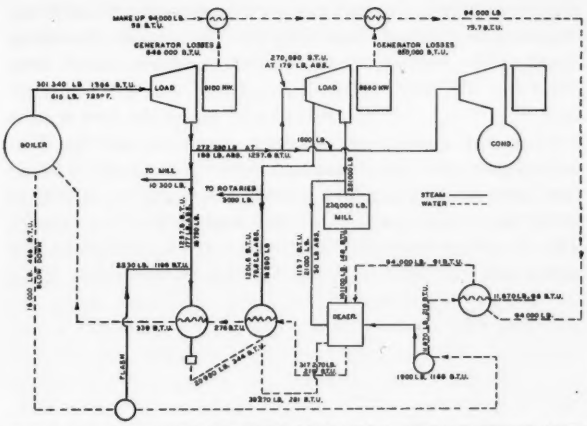


FIG. 17. GUARANTEED PERFORMANCE OF THE HIGH AND INTERMEDIATE TURBINE ELEMENTS AT MAXIMUM LOAD

12,000 lb. of coal per hour per burner has been handled for demonstration purposes.

Pulverizers and Feeders

Arrangement of the feeders, pulverizers and boiler control panel is based upon two general conclusions drawn from Mr. Randall's past experience with pulverized fuel and unit mills. First, that the most serious and troublesome difficulties are caused by wet or lumpy coal interrupting the feed at partial gate openings; second, that as the totally enclosed pulverizer, in itself, gives the operator no indication of its performance nor is he in a position to do anything but shut it off if anything goes wrong. The best guide he has is the power consumption of the driving motor.

With this in mind the feeders have variable, instead of constant speed, feed tables and the pulverizers are located on the level below the firing floor where they are out of the fireman's way. All coal is weighed by dust-proof automatic scales and dumped into the feeder hoppers. As can be seen from both the drawing Fig. 8 and the photograph Fig. 11, the hopper spouts have been cut short so that the coal flow to the feeder is visible to the fireman at all times. Each pair of feeders is driven by a 1.5-hp., 115-v., 400 to 1600-r.p.m. direct-current motor.

Boiler Panel

Control of the feeders, pulverizers and draft fans is from a central boiler panel on the firing floor as shown in Fig. 4. This panel in itself would distinguish the plant. Its simple and effective arrangement is self-evident from a short inspection of the center section alone which consists of a mimic diagram showing the flow of coal from the bunker through to the furnace; the flow of coal, air and gases into and out of the boiler; the flow of feedwater into the boiler and the flow of

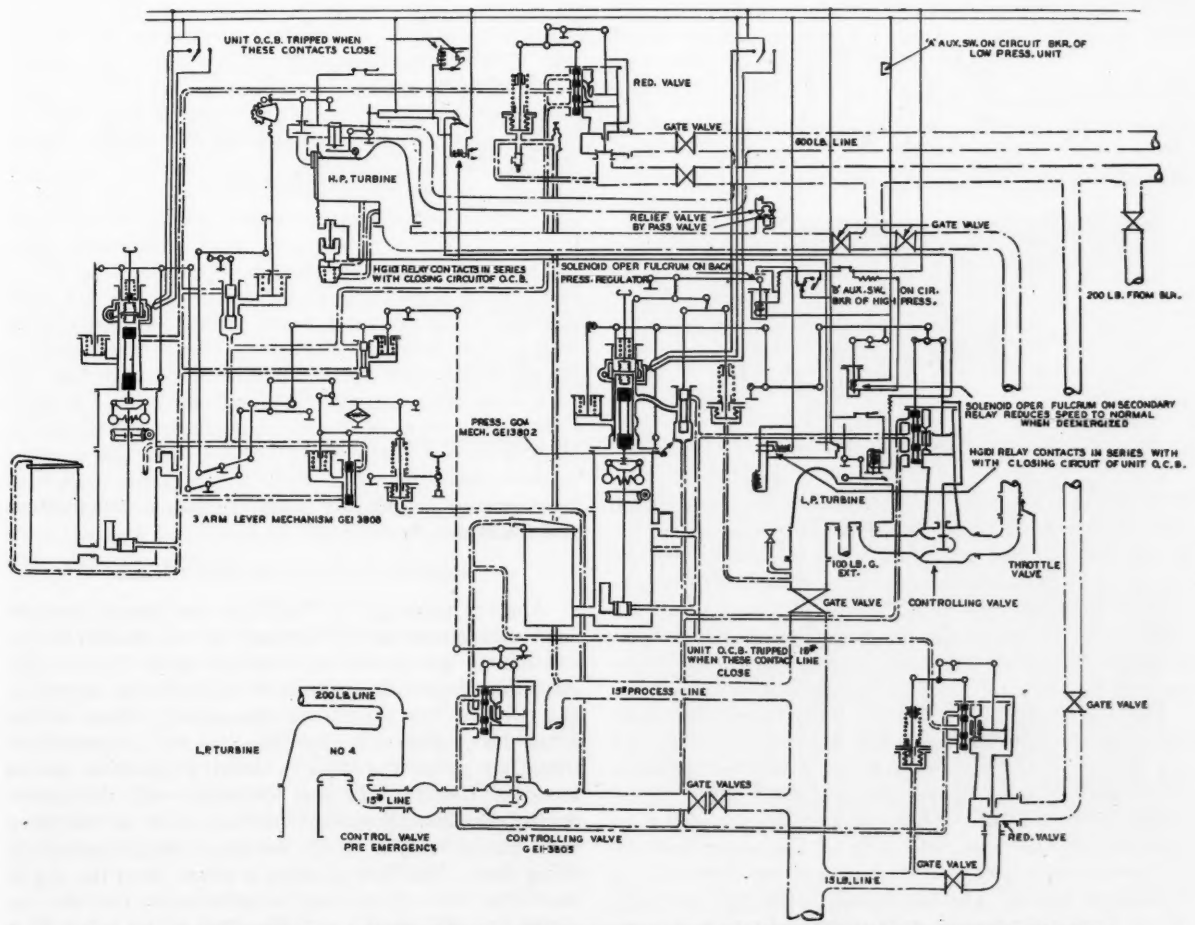

UNIT O.C.B. TRIPPED WHEN THESE CONTACTS CLOSE
'A' AUX. SW. ON CIRCUIT BKR. OF LOW PRESS. UNIT
RED. VALVE
GATE VALVE
600 LB. LINE
H.P. TURBINE
RELIEF VALVE BY PASS VALVE
GATE VALVE
HGIDI RELAY CONTACTS IN SERIES WITH CLOSING CIRCUITOF O.C.B.
SOLENOID OPER FULCRUM ON BACK PRESS. REGULATOR
'B' AUX. SW. BKR OF HIGH PRESS.
ON CIR.
200 LB. FROM BLR.
SOLENOID OPER FULCRUM ON SECONDARY RELAY REDUCES SPEED TO NORMAL WHEN DEENERGIZED
PRESS. GOV. MECH. GEI3802
HGIDI RELAY CONTACTS IN SERIES WITH WITH CLOSING CIRCUIT OF UNIT O.C.B.
3 ARM LEVER MECHANISM GEI 3808
L.P. TURBINE
100 LB. G. EXT.
THROTTLE VALVE
GATE VALVE
CONTROLLING VALVE
UNIT O.C.B. TRIPPED WHEN THESE CONTACTS CLOSE
15# LINE
15# PROCESS LINE
GATE VALVE
200 LB LINE
L.P. TURBINE
NO 4
15# LINE
GATE VALVES
CONTROL VALVE PRE EMERGENCY
CONTROLLING VALVE GEI-3805
RED. VALVE
GATE VALVE
15 LB. LINE

FIG. 18. DIAGRAMMATIC ARRANGEMENT OF THE HIGH AND INTERMEDIATE TURBINE GOVERNORS

steam out. Various wattmeters indicate the performance of the various machines. For instance, the four top wattmeters indicate the speed of the four feeders. From the feeders, the flow of coal is down through the mills, with the performance indicated by the second row of meters, and into the boiler. Operation of the forced and induced draft fans is shown by the two wattmeters at the side of the boiler. Alarms at the bottom of the panel indicate high and low water levels.

Each feeder can be controlled individually or by the master controller shown between the two center grips. couple installed so that any of the recording thermometers can be checked immediately. The six-pen recording chart at the bottom shows: steam pressure; steam temperature; air temperature in and out, and gas temperature in and out. On the right-hand panel the flow meters indicate the steam and feedwater flow respectively. The second two give the steam and feedwater pressure while the three integrating flow meters below show the flow of feedwater, continuous blowdown and steam respectively. The six-point recording instrument at the bottom of this panel shows: Steam flow; feedwater pressure; CO_2;

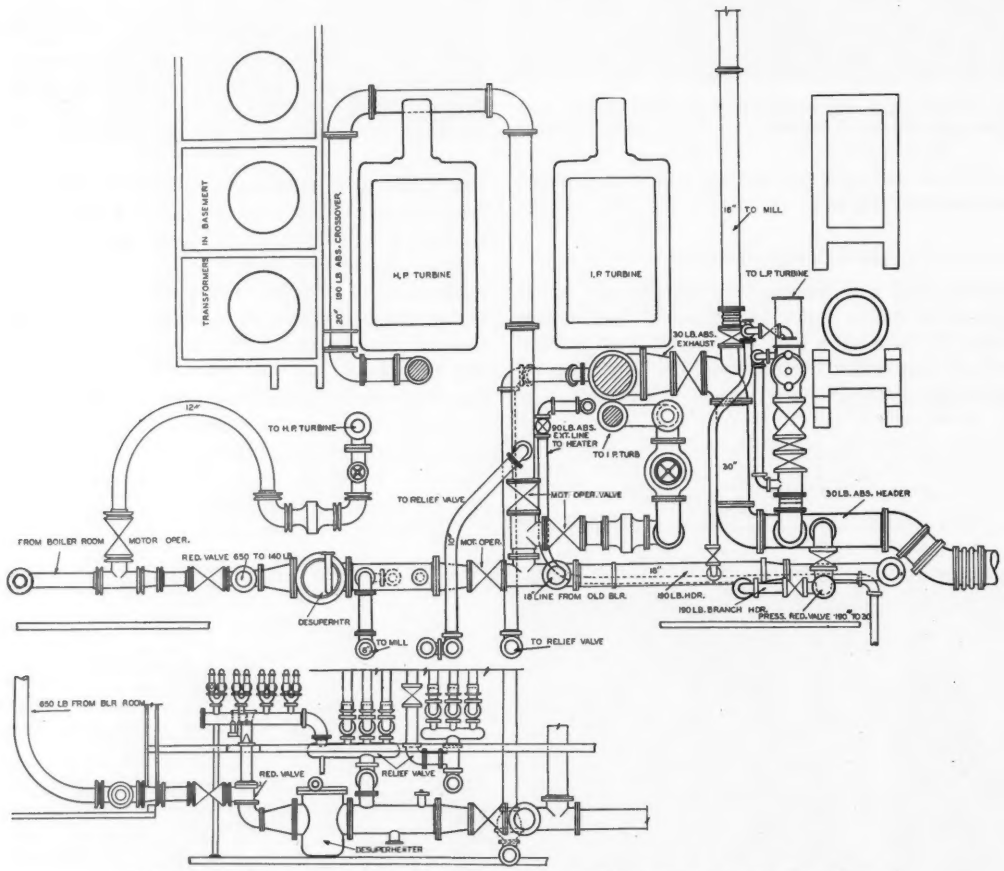


FIG. 19. ARRANGEMENT OF THE STEAM PIPING IN THE TURBINE ROOM

Pulverizers can be started or stopped by the push button immediately beneath the respective ammeters as can the forced and induced draft fans. The push button shown in the glass case below the boiler shuts down the entire plant and closes the boiler stop valve in case of an emergency. This can also be done from similar buttons placed elsewhere in the plant, one in the turbine room and another just inside of the boiler room door.

On the left-hand panel, the two top instruments indicate the flow through the continuous blowdown and the CO_2 respectively. Two recording instruments below these indicate and record the feedwater level in the drum. There is one feedwater regulator recorder on each end of the drum and both of the water level recorders are equipped with the high and low water alarms mentioned above. The instrument below the two feedwater level recorders is a 24-point indicating thermo- blowdown in pounds per hour; feedwater temperature and feedwater flow.

Forced and Induced Draft Fans

Another point which illustrates the logical arrangement and operating convenience of the station is the location of the forced and induced draft fans on the main floor immediately back of the boiler as shown by Fig. 13 with the controllers immediately above on the firing floor. This not only simplifies the structural design, but gives the fans a solid foundation in an accessible location. In case of trouble with the remote control, the manual control, directly above on the firing floor, can be reached by the fireman without leaving the firing floor. The flow of gases is down, from the top of the boiler, through the air heater directly into the top of the induced draft fan. The flow of air is up from

the forced draft fan through the air heater into the preheater air duct which splits with one branch around each side of the boiler to the burner.

Stack Spray

Gases are discharged from the induced draft fan direct to the base of a 225-ft. brick stack which was used with the old plant. Stack sprays are provided for the elimination of fly ash so the stack has been lined with vitrified tile and acid proof cement. As shown in the detail at the top of Fig. 8, the breeching, where it enters the stack, has been fitted with downward curved deflector plates to precipitate the larger ash particles. A single spray, consisting of a pipe drilled with $\frac{7}{32}$-in. dia. holes located as shown has proved to be so effective that another spray installed higher up in the stack is unnecessary.

Screen tests of solids in the gas just before the stack at the discharge of the induced draft fan show the following: Through 24 mesh, 99.6 per cent; through 48 mesh, 99.2 per cent; through 100 mesh, 94.8 per cent; through 200 mesh, 85.2 per cent; through 325 mesh, 66.4 per cent. Combustible in this ash ranges around 10 per cent, as compared with 3 to 5 per cent combustible in the ash taken from the bottom of the furnace.

At maximum rating, the gas velocity up the stack is about 33 ft. per sec., or 2000 ft. per min. At average rating, this drops to about 25 ft. per sec. or 1500 ft. per min. In the breeching between the induced draft fan and the stack, the velocity is about 30 ft. per sec. or 1800 ft. per min. at normal rating. This high velocity is sufficient to carry moisture particles up the stack and when considering stack sprays this factor must never be overlooked. An inspection of Fig. 8 will show that in this installation the gas flow entering the stack is downward, followed by a sharp bend upward so that moisture or ash particles which might otherwise be carried along in the gas stream are precipitated out as in a steam separator.

Water from the stack spray is sluiced down to the tank, Fig. 6. Here the solid particles settle out and the water runs over a weir into the sewer. Solid particles are taken up by the grab bucket, loaded into a push cart and dumped in a skip hoist for elevation to the ash bunkers. Ash from the ashpit is handled the same way, that is discharged through the ash gates to a buggy and taken to the skip hoist. The skip hoists were part of the ash handling system of the old plant; they were in good condition and the small amount of ash expected from the new boiler did not warrant the expense of a more elaborate system.

Ventilation

Both the main and basement floors are sloped so that they will drain when sluiced down with a hose. The basement floor is of concrete with Klemp grating imbedded flush with the concrete in places where the ash buggy runs. The main floor is of terraza. Above the ground all floors are made of Klemp grating; a skylight in the roof is located so that it serves the double purpose, as shown by Figs. 8 and 14, of ventilating the boiler room and giving space for removal of the air heater tubes.

In order to facilitate the handling of pieces too large to fit in the boiler room elevator, which serves all floors,

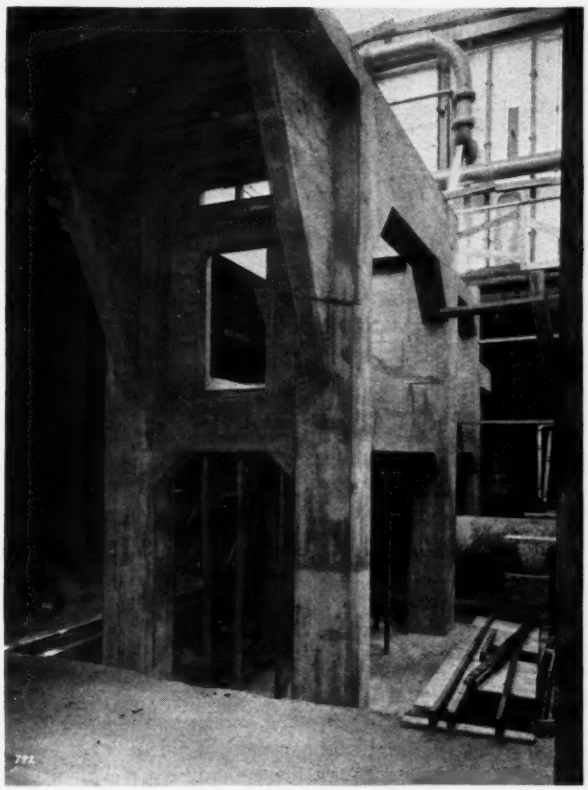


FIG. 20. RE-ENFORCED CONCRETE FOUNDATION OF THE HIGH-PRESSURE ELEMENT

an I-beam, shown sticking out of the upper left-hand corner of the headpiece, has been built in. Full length doors open out from each floor and by means of a block and tackle, equipment too large for the elevator can be

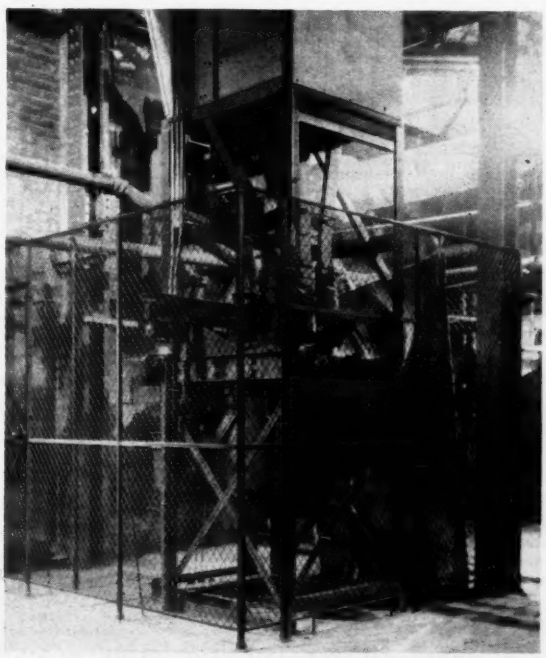


FIG. 21. OIL SWITCHES AND DISCONNECTS ARE PLACED DIRECTLY BELOW THE SWITCHBOARD AND BACK OF THE GENERATOR

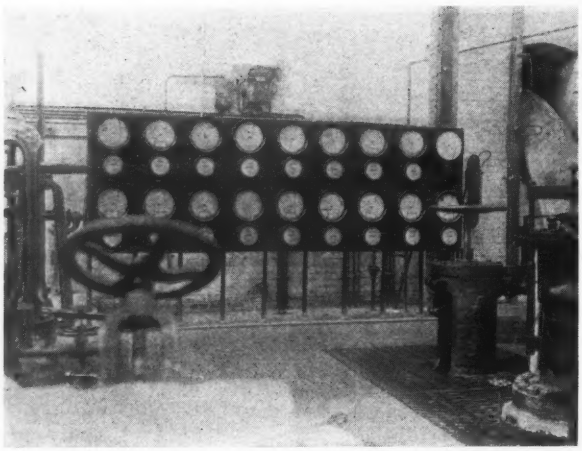


FIG. 22. FLOW CONDITIONS THROUGHOUT THE PLANT ARE SHOWN BY 17 FLOWMETERS GROUPED ON ONE BOARD

hoisted in or out. In fact, I-beams of this kind have been installed in all locations not accessible to the crane, for instance, at the boiler front as shown in Fig. 15 and over the pulverizers as shown in Fig. 12.

Feedwater System

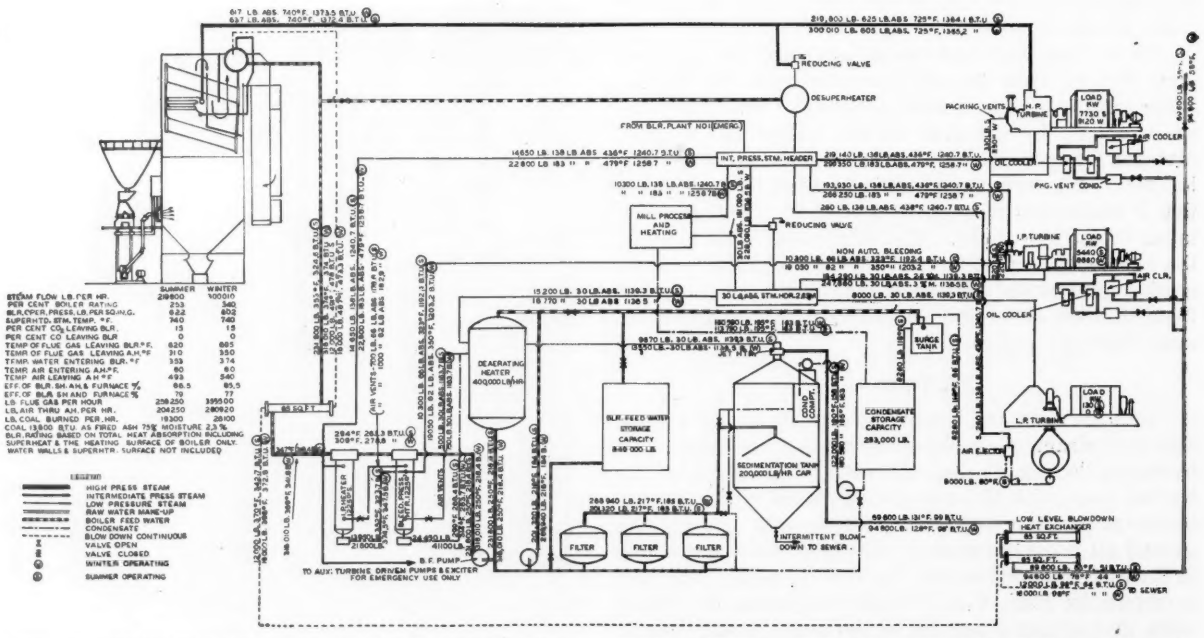
Feedwater treating, heating and pumping equipment is installed in the turbine room. Makeup well water enters the system through the generator air coolers, the 88-sq. ft. gland steam condenser, the turbine oil cooler and two sections of continuous blowdown to the top of the water softener tank. In case the makeup water demands fall below the needs of the air and oil coolers, excess water is stored in a tank in the basement for later use in the mill.

Softened water passes through the filter to the mill softened water system, the deaerating feed heater, or storage tanks as conditions demand. Condensate from the condenser is used in the overhead gland water tank and the overflow goes direct to the deaerating heater. Condensate return from the mill is stored in tanks similar to the filtered water tanks as shown in the plan in Fig. 1. From these tanks, the feedwater supply is pumped to the condensate compartment of the softener and then to the deaerating heater located above the boiler feed pumps.

Three similar and interchangeable boiler feed pumps are installed. They are six-stage Camerons, pumping against a head of 1800 ft. One is driven by a Westinghouse 400-hp., 2200-v. induction motor at 1765 r.p.m. while two are driven by 498-hp., 175-lb. Terry turbines at 1850 r.p.m. The pumps are interchangeable and deliver 600 g.p.m. at 1765 r.p.m. or 760 g.p.m. at 1850 r.p.m. In normal operation, the motor driven unit operates. The two steam driven units are fitted with S-C pump governors and in case of a drop in feed line pressure first one and then the other turbine unit is started automatically.

From the pumps the water goes through the 1225 sq. ft., 90 lb. extraction heater, the 1225 sq. ft., 190 lb. cross over pressure heater and the top section of the continuous blowdown heater to the boiler. Both the Elliott vertical extraction heaters and the Henszey continuous blowdown heat exchanger are shown in Fig. 16.

Softening equipment is a Cochrane hot process lime and soda ash system. Agitation tank and chemical pumps are located between the softening tank and the deaerating heater on the main floor and immediately above the filters. Phosphate pumps which discharge through a separate line direct to the boiler drum are



STEAM FLOW LB. PER HR.	SUMMER 219800	WINTER 300010
PER CENT BOILER RATING	253	340
BLR.OPER.PRESS.LB.PER SQ.IN.G.	622	602
SUPERHTD. STM. TEMP. °F.	740	740
PER CENT CO_2 LEAVING BLR.	15	15
PER CENT CO LEAVING BLR.	0	0
TEMP OF FLUE GAS LEAVING BLR.°F.	620	685
TEMP OF FLUE GAS LEAVING A.H.°F	310	350
TEMP. WATER ENTERING BLR.°F	353	374
TEMP. AIR ENTERING A.H.°F.	80	80
TEMP. AIR LEAVING A.H.°F	493	540
EFF. OF BLR. SH. AH. & FURNACE %	86.5	85.5
EFF. OF BLR. SH AND FURNACE %	79	77
LB. FLUE GAS PER HOUR	259250	395500
LB. AIR THRU AIR PER HR.	204250	280920
LB. COAL BURNED PER HR.	19300	28100

COAL 13800 BTU AS FIRED ASH 7.5% MOISTURE 2.5%
BLR. RATING BASED ON TOTAL HEAT ABSORPTION INCLUDING SUPERHEAT & THE HEATING SURFACE OF BOILER ONLY.
WATER WALLS & SUPERHTR. SURFACE NOT INCLUDED

FIG. 23. HEAT BALANCE AND FLOW DIAGRAM FOR A WINTER CONDITION (20 DEG. F. OUTSIDE TEMPERATURE) WITH A LOAD OF 17,980 KW. AND A STEAM FLOW OF 300,000 LB. PER HR. SURPLUS POWER WILL BE SOLD AS DUMP POWER. SUMMER CONDITION FOR A LOAD OF 13,300 KW. AND A STEAM FLOW OF 219,800 LB. PER HR. THIS IS THE LIGHTEST SUMMER CONDITION. THIRTY PER CENT LOW WATER MAKEUP IN EACH CASE

List of Equipment at the Champion Coated Paper Co. Plant

BOILER ROOM

1 Babcock & Wilcox Co. 900-lb. cross drum boiler, 45 sections wide, 22 tubes high with total heating surface 27,192 sq. ft. made up of 4-in. tubes 22 ft. long and baffled for three passes. Inside calked drum 54 in. dia., 34 ft. 1 in. long. Alternate tubes in the bottom row bent to form a slag screen. Output at maximum rating of 400 per cent, 343,000 lb. of 650-lb. ga., 750-deg. F. steam per hour.
1 Babcock & Wilcox Co. 5300-sq. ft. convection superheater located between the fifth and sixth rows.
1 Babcock & Wilcox Co. 47,742-sq. ft. tubular air heater.
1 Fuller Lehigh Co. water-cooled furnace with a total volume 19,080 cu. ft. Total water cooled surface 2620 sq. ft. made up of two sidewalls, downtake wall and hopper floor and uptake hopper floor designed for a maximum heat delivery about 24,000 cu. ft. per hr.
4 Riley Stoker Corp. pulverizers with a capacity of 10,000 lb. per hr. each based on coal with grindability of 65 referred to Pocahontas as 100, driven by 125-hp., 2300-v. Westinghouse induction motors.
4 Riley Stoker Corp. No. 5 special burners with capacity of 150,000,000 B.t.u. per hr. with 575 deg. secondary air.
4 Riley Stoker Corp. duplex feeders with variable speed magnetic feed table driven by a Westinghouse 1.5-hp., 115-v., d.c., 400 to 1600-r.p.m. motor.
4 Richardson Scale Co. dustproof automatic scales.
1 Green Fuel Economizer Co. No. 68, type RB, design C-2, double inlet, full housed forced draft fan with capacity of 400,000 lb. of gas per hr. at 9 in. static pressure. Driven by a Westinghouse 200-hp., 820-r.p.m., 2300-v. motor.
1 Green Fuel Economizer Co. No. 11½, type SA, double inlet, single width, induced draft fan with capacity 500,000 lb. of gas per hr. at 6 in. static pressure, driven by a Westinghouse 400-hp., 2300-v., 354-r.p.m. motor.
2 Swartwout Co. feedwater and excess pressure regulators, one on each end of the boiler drum.
1 Allen-Sherman-Hoff Co. ash hopper with hydraulic operating gates.
Damper control ....Carrick Engineering Co.
Soot blowers ....Diamond Power Specialty Corp.

TURBINE ROOM

1 20,000-kw. triple element turbine consisting of:
1 General Electric Co. high-pressure element. A 9375-kv-a., 2300-v., 3600-r.p.m., 3-phase, 60-cycle generator, with a direct-connected 125-v., 40-kw. exciter, driven by a 600-lb., 725-deg. F., 175-lb. ga. back pressure eight stage turbine.
1 General Electric Co. intermediate-presure element. A 9375-kv-a., 2300-v., 3600-r.p.m., 3-phase, 60-cycle generator with a 125-v., 40-kw. direct-connected exciter driven by a 200-lb. pressure, 725-deg. F. 15-lb. ga. back pressure, six-stage turbine with one stage of extraction at 75 lb. ga. pressure.
1 Westinghouse Elec. & Mfg. Co., low-pressure element. A 875-kv-a., 440-v., 3-phase, 60-cycle, 1800-r.p.m. generator driven by a condensing turbine receiving steam at 15 lb. ga. pressure. (This unit was purchased 15 yr. ago.)
1 C. H. Wheeler Mfg. Co. single pass 3500-sq. ft. surface condenser (10 yr. old).
1 Elliott Co. two-stage twin air ejector with combined inner and after cooler (5 yr. old).
1 Elliott Co. hotwell pump driven by 7.5-hp., 3500-r.p.m., 440-v. Reliance motor.
2 General Electric Co. 75-kw., 125-v. compound wound exciters. One driven by a Terry 185-lb. ga., 18-lb. back pressure, 75-kw., 1200-r.p.m. turbine and the other driven by a 115-hp., 2200-v., 1200-r.p.m. General Electric motor.
2 General Electric Co. closed type generator air coolers.
1 Spraco Generator air washer on the lower pressure element, supplied with water by a Buffalo Steam Pump Co. 20-g.p.m., 1740-r.p.m., 60-ft. head, single stage pump driven by a Reliance 5-hp., 440-v. motor.
4 Andale Engineering Co. turbine oil coolers.
2 Elliott Co. 55-sq. ft. single pass gland steam condensers designed for 100 lb. water pressure, 15 lb. ga. steam pressure and a head loss of 12 ft. at 150 g.p.m.
1 Elliott Co. 24-in., 250-lb. cartridge type desuperheater with a capacity of 350,000 lb., of 175 lb. ga. pressure, 700 deg. F. total temperature steam per hour. Equipped with Swartwout Co. S-C water regulating valve.
3 Ingersoll-Rand Co., Cameron, 4-HST-6 boiler feed pumps. These pumps are interchangeable; one is driven by a 400-hp., 2200-v., 1765-r.p.m. Westinghouse motor; the other two are driven by Terry 498-hp., type C-2, 175-lb. ga., 15-lb. ga. back pressure, 850-r.p.m. turbines. Pump capacity at 1765 r.p.m. and 1800 ft. head, 600 g.p.m.; capacity at 1850 r.p.m. and 1800 ft. head, 760 g.p.m.
1 Cochrane Corp. 2400-g.p.h. hot process water softener.
1 Hagan Corp., Hall system of secondary phosphate treatment.
1 Cochrane Corp. deaerating heater.
2 Elliott Co. 1225-sq. ft., 2-pass, extraction heaters with capacity of 350,000 lb. per hr. Designed for 900 lb. working pressure, tube length 12 ft. 6 in.
1 Henszey De-Concentrator Co. continuous blowdown system.
2 DeLaval Steam Turbine Co. centrifugal pumps for delivering water from the storage tanks to the deaerating heater.
2 De Laval Steam Turbine Co. centrifugal pumps for delivering water from the softener to the storage tanks.
Heater drains....Atwood & Morrill Co.
Boiler feed pump governors, S-C.... ..... Swartwout Co.

COAL HANDLING

1 Stephens-Adamson Mfg. Co., 14 by 12 ft. track hopper.
1 American Pulverizer Co., type S crusher driven by a 60-hp., 440-v., 690-r.p.m. Westinghouse motor.
2 Stephens-Adamson coal feeders driven by 50-hp., 440-v., 715-r.p.m. Westinghouse line start motor through a D. O. James Mfg. Co. 1800 to 300-r.p.m. speed changer. The first feeder, 30 in. wide with 9 ft. 1 in. centers, is of the apron type with overhanging pans driven up a 25-deg. incline at a speed of 13½ f.p.m. and feeds coal from the track hopper to the crusher. The second feeder is a belt 30 in. wide with 12 ft. 2 in. centers and a capacity of 60 t. per hr. It is driven at a speed of 175 f.p.m. This feeder equipped with a magnetic pulley takes the discharge of the crusher and deliver it to the elevator. (Old.)
1 Stephens-Adamson gravity discharge elevator with capacity of 60 t.p.h. This consists of 20 by 20-in. V-buckets, 24 in. apart on a 12-in. pitch roller chain. It is driven at 100 f.p.m. by a 15-hp., 1160-r.p.m., 440-v., Triumph motor through a texrope drive. (Old.)
1 Link-Belt Co. screw feeder and conveyor driven by a Westinghouse 25-hp., line start, 1160-r.p.m., 440-v. motor through an Ajax flexible coupling and a single herringbone speed reducer with a ratio 5.8 to 1. A 16-in. Helicoid feeder, 13 ft. long with rack and pinion discharge gates and Timken thrust bearings, takes the discharge of the bucket elevator and discharges it either to a belt conveyor for the old bunker or the screw conveyor for the new bunker. The conveyor to the new bunker is a 16-in. Helicoid conveyor 104 ft. long with Timken thrust bearings rack and pinion discharge gates and a capacity of 70 t. per hr. at 80 r.p.m.
1 Stephens-Adamson Mfg. Co., 24 in. wide on 166 ft. 7 in. centers, belt distributors with self-propelling tripper and a 2-way spout. Driven by a 7.5-hp., 1160-r.p.m., 440-v., Triumph motor at a speed of 250 f.p.m. Capacity of 60 t. per hr.
2 Link-Belt Co., 16-in. Helicoid reclaim conveyors, 158 ft. long with Timken thrust blocks and capacity of 70 tons per hr. at 80 r.p.m. Driven by Westinghouse 30-hp., 440-v. line start motor, through an Ajax flexible coupling, a herringbone speed reducer and roller chain drive arranged so that but one conveyor can operate at a time.
2 Link-Belt Co., 26-in. portable feeders for feeding the above conveyors.
1 Blaw-Knox Co., single line bucket for ash.
2 R. H. Beaumont Co., ash skip hoists with capacity of 7 t. per hr. at 75 f.p.m. cable speed. Driven by 7.5-hp., 970-r.p.m., 440-v., Westinghouse motors. (Old equipment.)

VALVES

. Wm. Powell Co., motor-driven steam valves with Cutler-Hammer Co. control.
1 Chapman Valve Mfg. Co., motor-driven steam valve.
1 Schutte & Koerting Co., boiler stop valve with remote electrical control.
1 Babcock & Wilcox Co., tanden blow-off valve on mud drum.
6 Yarnall-Waring Co., blowoff valves on boiler walls; two on back wall header, two on front wall header, and one on each side wall header.
8 Consolidated Ashcroft Hancock Co., Inc., safety valves; 6 on the boiler drum; 2 on the superheater.
Steam valves.....Wm. Powell Co. .....Consolidated Ashcroft
Small forged steel valves..... Hancock Co., Inc.
Pressure reducing valves..... .....General Electric Co.
Atmospheric relief valve..... ..... Cochrane Corp.
Boiler feed line check valves..... .....Smolensky Valve Co.
Feedwater line fittings..Walworth Co.
Feed line valves.....Wm. Powell Co.
Service water reducing pressure valves ....Swartwout Co.
Traps.....Armstrong Co. .....Johns-Manville Corp.
Safety valves on intermediate pressure header....Consolidated Ashcroft Hancock Co., Inc.

INSTRUMENTS

Steam and pressure gages..... .....Cleveland Steam Gauge Co. .....Consolidated Ashcroft Hancock Co., Inc. .....United States Gauge Co.
Recording pressure gages...Bristol Co.
Indicating thermometers .... Consolidated Ashcroft Hancock Co., Inc. .....Taylor Instrument Co.
Indicating pyrometers ....Republic Flow Meters Co.
Draft gages ....Defender Automatic Regulator Co. ..Hays Corp. ..Republic Flow Meters Co.
Feedwater level recorders..Foxboro Co.
Flowmeters..Republic Flow Meters Co.
CO_2 meters...Republic Flow Meters Co.
Strip chart records (6 pen)..... .....Republic Flow Meters Co.
Instrument pressure fittings..... .....Parker Appliance Co.
Electric instruments.....Bristol Co. .....Esterline Angus .....General Electric Co. .....Westinghouse Elec. & Mfg. Co. .....Weston Electric Co.
Voltage regulator..General Electric Co.

PIPING

Piping.....National Valve & Mfg. Co. .....Crane Co.
Insulation.....Keasbey & Mattison Co. .....Johns-Manville Co.
Floor grating.....W. F. Klemp & Co.
Structural steel ....Massillon Bridge & Structural Co.
Chain blocks.....Cyclone Block Co. .....Harrington Purles Co.
Oil pumps for pulverizers..... .....Viking Pump Co.
Oil centrifuges ....DeLaval Steam Turbine Co.
Oil storage tanks..... .....S. F. Bowser Co., Inc.
Oil switches...Condit Electric Mfg. Co.
Pot heads and closed switch and junction boxes.....Line Material Co. .....Elect. Engrs. Equip. Co.
Cables.....Safety Cable Co. .....Anaconda Wire & Cable Co.

close by. The arrangement of the steam, feed, phosphate and blowdown lines is shown in Fig. 1.

One of the most difficult feats was the location of the turbine, steam piping, reducing valves and desuperheater in the limited space available in the turbine room. Provision had to be made to carry the electric load when the high pressure element is down or to supply steam to the two process lines when the electric load is light. This meant a reducing valve from the 600 to the 175-lb. ga. system and from the 175 to the 15-lb. ga. system. Furthermore, although the intermediate pressure machine is designed for a maximum temperature of 750 deg. F. the old No. 1 and No. 2, 175-lb. turbines, which will sometimes have to be used, were not. To take care of this an Elliott cartridge type desuperheater with a capacity of 350,000 lb. per hr. was installed with the water supply, from the discharge of the feed pumps, under the control of an S-C regulator.

Turbine Room

As noted above, three old turbo-generators were left in place and serve as standby units. These are two 2500 kv-a., 185-lb. ga. noncondensing and one 7500 kv-a., 185-lb. ga. condensing units so that with these and the old 200-lb. boiler equipment there is plenty of standby capacity for both boiler and turbine. In normal operation the three turbine elements are operated as one and governed from the high pressure element by the governor system shown diagrammatically by Fig. 18. In an emergency, any of the three elements can be operated separately under the control of the regular speed or speed and back pressure governor.

A diagram of the turbine piping is shown in Fig. 19. The limited space between the high and low pressure element, allowed no provision for expansion so that the 175-lb. ga. cross over line, i.e., the discharge of the high-pressure element, was carried entirely around the generator end of the machine as shown. The 200-lb. line from the old boilers, the process lines, the 90-lb. abs. bleeder line from the intermediate element, the second reducing valve and the 15-lb. ga. header are also indicated in this drawing. Figure 20 is a photograph showing the arrangement and design of the high pressure turbine foundation.

The switchboard shown in Fig. 2 is the new 15 panel black slate section just installed. In addition, there is the original 24 panel black slate section which carries the voltage regulator. Both the high and intermediate pressure machines are equipped with direct connected 40-kw., 125-v., compound wound exciters but two separately driven 75-kw., 1200-r.p.m., 120-v., General Electric exciters, one driven by a 115-hp., 2300-v. motor and the other by a Terry 185-lb., 75-kw. turbine, are also installed.

Oil switches and disconnects were installed under the switchboard directly in front of the generator as shown in Fig. 21. Generator leads are brought out through a transite duct to the switches and directly up to the bus as shown making a direct, compact and accessible arrangement.

Turbine Guarantees

Because of the complicated nature of the machine and the flow diagram, turbine guarantees in the usual manner were impractical and the diagram Fig. 17 was used for showing the performance of the high and intermediate elements at a load of 17,980 kw. The equipment was not installed exactly as shown; for instance the blowoff system was changed to a closed heater type in the final design but the figures given indicate the performance of the turbines.

Flow diagrams and heat balances of the plant for both winter and summer conditions are shown by Fig. 23. Under average operating conditions, preliminary tests indicate a boiler efficiency of between 86 and 87 per cent. The expected performance of the unit is shown by Fig. 9. Because of the short time the plant has been in operation, it has been impossible to make complete tests over the entire load range but a preliminary boiler heat balance shows at normal load:

Absorbed by boiler and superheater	86.80 per cent
Loss due to moisture	0.20 per cent
Loss due to hydrogen	3.80 per cent
Loss due to dry chimney gas	6.60 per cent
Loss due to moisture in air	0.10 per cent
Loss due to unburned fuel	0.50 per cent
Loss due to radiation unaccounted for	2.00 per cent
Total	100.00 per cent

A crew of 10 men per watch operate the plant. In the boiler room: watch engineer; water tender; fireman; helper; ash man. In the turbine room: watch engineer; oiler; helper; water softener engineer and pump man. Every aid to efficient operation has been provided; for instance, the three large gages shown in the background of Fig. 3 are duplicates of the turbine room gages and tell the firemen the pressure conditions in the high, intermediate and low pressure steam systems. Similarly, flow meter indicators in the pump room, also visible in the turbine room, show the flow of steam, feedwater and continuous blowdown. A flow meter instrument board, Fig. 22, with 17 grouped flow meter recorders, indicates to the engineer, load conditions in all parts of the mill.

This development, and it is evident that this is one of the few power plants which can boast not one but several really constructive steps forward in power plant design, is one of the finest possible examples of plant rehabilitation, a term which is becoming of increased importance in both utility and industrial work. To scrap an old plant and build an entirely new one is comparatively simple but to rebuild an old plant, use the old equipment to full advantage and add sufficient new equipment to make it stand head and shoulders above even an entirely new one is a task which is worthy of respect. The Champion Coated Paper Co. is to be congratulated on its far sighted policy. Officers of the company are: Peter G. Thomson, president; Walter D. Randall, vice-president and mill manager; Alexander Thomson, vice-president and manager of sales; Logan G. Thomson, secretary and treasurer; Herbert T. Randall, assistant mill manager in general charge of the various maintenance and construction departments which handled a large part of the construction work.

Development of the pressure gun has had a distinct bearing on design of equipment. It can be used or designed as a directly connected unit or as a portable gun and is of decided value in reducing labor costs and improving lubrication.

Process Steam for a Hat Plant

Power as a By-Product at Low Cost. By Francis A. Westbrook*

PRODUCTION of felt hats can hardly be rated as a heavy operation, yet a well designed power plant of no mean proportions is essential. This, of course, is because much process steam is necessary as well as electrical energy for power and heating.

One unusually good and up-to-date example of an economical steam plant of this kind is the installation, made by Fletcher-Thompson, Inc. of Bridgeport, Conn., at the Hodshon-Berg unit of the Cavanagh-Dobbs Corporation at East Norwalk, Conn. This is an entirely new three-story plant, having a floor space of 160,000 sq. ft. with a capacity for turning out 500 dozen hats per day.

At this plant, the process steam could have been furnished in two ways:

(1) From a reducing valve, the power being obtained from some other source or purchased.

(2) From the exhaust of a steam turbine, which is the system selected.

Suppose that 18,000 lb. of steam per hour at 20 lb. pressure is required. Pass this through a reducing valve as per plan (1). The B.t.u. available will then be, at steam condition of 200 lb. and 150 deg., (1285 — 227) $\times$ 18,000 = 19,000,000 B.t.u.

Now if system (2) is employed:

The water rate of the turbine is 40.8 lb. per kw-hr. With 18,000 lb. of steam, therefore, 440 kw. will be developed. But the turbine takes 84 B.t.u. out of each pound of steam that passes through it or at the exhaust there will be (1201 — 227) $\times$ 18,000 = 17,500,000 B.t.u.

In order to obtain the same number of B.t.u. as in plan (1), it will be necessary to pass 1058 $\div$ 974 $\times$ 18,000 = 19,600 lb. of steam per hr. through the turbine.

But this extra 1600 lb. develops 39 kw., so that the total power then equals 440 + 39 = 479 kw.

If we assume that 8 lb. of coal will make 1 lb. of steam, we have, 1600 $\div$ 8 = 200 lb. of coal extra that system (2) requires over system (1); or 200 $\div$ 479 = 0.418 lb. of coal per kw-hr.

This should be compared with the 1 lb. of coal per kw-hr. that the largest central stations obtain.

Boiler Plant

At the present time two Bigelow boilers, each 385 hp. and operating at 225 lb. pressure, have been installed and foundations have been constructed for two more. They are stoked by means of Combustion Engineering Co. Type E automatic stokers served by a 2-t. L head monorail coal carrier. The boilers are also provided with Hagan combustion control, Copes feedwater heaters, Davidson feed pumps and the usual gages in the boiler house and recording instruments in the turbine room found in all modern plants. In addition there is a Clarage forced draft blower large enough to supply the ultimate four boilers. This is driven by a 1200-r.p.m., direct-connected, 56-hp. Terry turbine, operating at 225 lb. pressure and 15 lb. back pressure.

Turbines

Process steam in the plant is required at about 15 lb. and the boiler pressure is reduced by means of turbines

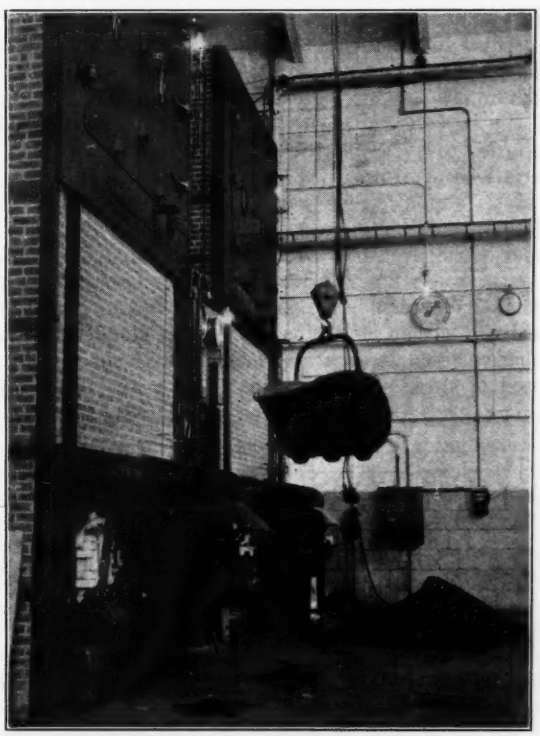


FIG. 1. MONORAIL COAL CARRIER AND STOKERS IN 800-HP. PLANT

which supply the full operating electrical load. This method of providing process steam and electrical energy was adopted in this new plant largely as the result of the successful results obtained by a similar method employed at the Crofut & Knapp unit of Cavanagh-Dobbs, which was placed in service about 6 yr. ago. It is one of those special manufacturing conditions where, on account of the large amount of process steam called for, it is possible to generate power with good economy, as the most careful analysis and check-up of both the company and central station engineers has shown. In many other special cases, more or less similar, the isolated plant will be the more economical and good engineering demands that each case be considered on the basis of the individual operating conditions.

In this installation the steam is reduced in pressure through two 500-kw., direct-connected Terry turbine units. These turbines are six stage machines, operating

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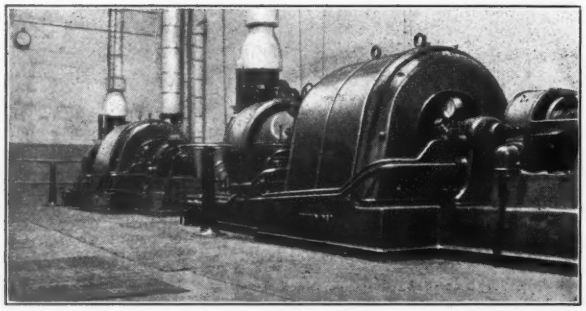


FIG. 2. BACK PRESSURE TURBINES FURNISH PROCESS STEAM

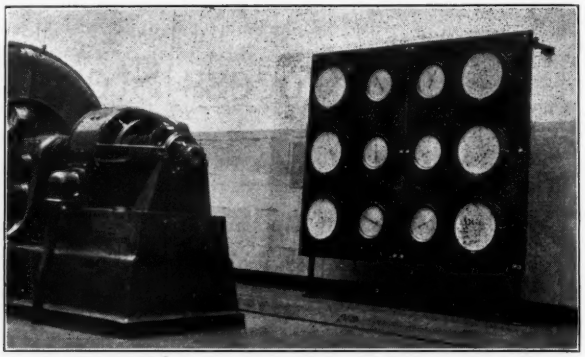


FIG. 3. STEAM FLOW AND PRESSURES ARE RECORDED AND MEASURED ON CENTRAL BOARD

at 200 lb., 150 deg. superheat and 20 lb. back pressure and run at 3600 r.p.m.

This type of turbine was selected as suitable for the accommodation of large or small quantities of steam at high or low pressures because of rugged features. It is of the impulse type with liberal blade clearances and, in order to avoid misalinement of the bearings due to variations of temperature and pressure in the turbine case, is supported on pedestals mounted on the base plate. Glands, diaphragms, bearings, bearing caps and other parts are split horizontally throughout so that, when the upper part of the cover is removed, the parts are easily accessible. Labyrinth interstage glands are used and carbon ring type for the end glands, the rings being enclosed in separate casings and each being composed of three segments held together by Monel metal garter springs. The shaft is of high carbon steel and of large diameter so that the critical speed will be safely above operating speed, with steel disk wheels having heavy hubs and pressed on this shaft. The first wheel of the velocity stage is bolted to the hub so that it may be removed when the blades become worn.

In the turbine room, the meter board consists of two panels, each provided with three recording and three non-recording meters. The recording meters show the saturated steam and turbine steam taken from the boilers, the amount of water used and the temperature of the feedwater. The non-recording meters show the pressures of the high-pressure steam, process steam, heating steam, compressed air and city water.

Compressed Air for Industrial Hoists and Lifts

CAPACITIES, AIR SUPPLY, SPEEDS AND CARE. BY H. L. KAUFFMAN

AIR-OPERATED hoists for easier handling of materials are used in numerous ways in factory plants, two types, air-motor hoists and direct-acting cylinders or cylinder and piston hoists being most common.

In the former, a high-power air motor is geared through a mechanical train to the hoisting drum. Less air is required for the operation of air-motor hoists than for those of the cylinder-and-piston type. Table I gives values for cylinder hoists of Hanna Engineering Works with 10 per cent allowance in air consumption for possible drop in pressure.

For air motor hoists, about 1.85 cu. ft. of free air are required to raise 1 t. for 1 ft., based on 230 cu. ft. to lift 2000 lb. at 124 ft. a min. with 80 lb. pressure. It is important that ample compressor capacity be provided if heavy loads are to be lifted rapidly as otherwise pressure will drop during the lift and the load may stall the hoist. The stalling point can be pushed up by use of an auxiliary receiver of suitable capacity, preferably installed near the air motor hoist. For instance, with a compressor which might allow stalling after 25 sec. on 750 lb. load, 12 sec. on 1500 lb. load and 7 sec. on 2000 lb. load, the use of a receiver could raise these times to 130 sec. for 750 lb., 95 sec. for 1500 lb. and 38 sec. for 2000 lb.

Speed of lift will increase with air pressure, also consumption of free air but high pressures are more economical than low in proportion to power delivered since air consumption increases with pressure more slowly than hoisting speed. Figure 1 shows the relation of lifting speed to air pressure for a 6½-hp. motor at various loads. Table II gives air consumptions and speeds for various air pressures of the Turbinair hoist of Sullivan Machinery Co.

Direct-acting cylinder hoists are frequently classified as being of either the pendant or the bracketed type. Pendant hoists have suspension lugs in the top head, with loop, swivel and hook at the lower end of the piston rod and valve attached to the lower end of the cylinder. Bracketed hoists, Fig. 2, have supporting feet for attaching to cranes, columns, walls, ceilings or platens. The end of the piston rod is threaded and may be equipped with yokes for either one, two or three sheaves for multiple lifts of 2 to 1, 4 to 1, or 6 to 1. The valve may be attached to or detached from the hoist and placed in any convenient operating position. Bracketed hoists are generally equipped with oversize piston rods, when used to push loads where there is a possibility of side strain on the rod, or in hoists having a long stroke. Loads and air consumption are practically as in Table I.

In the cylinder type of hoist, about the only part

subject to wear is the piston packing. To minimize wear at this point and to facilitate the replacement of a piston packing, in one design the cup leather is expanded or seated against the cylinder wall independent of air pressure. A square expansion ring maintains the packing against the cylinder wall, while a round expansion ring supports the packing above the fillet. Both rings are held in place by a follower and the piston is lipped near the edge to support the packing on the outside below the fillet. With this construction, when piston-packing replacement becomes necessary, the piston can be removed from the cylinder without dismantling the hoist.

In the piping of all hoists a check valve should be arranged to prevent dropping of the load, in case there is sudden interruption of the air supply. Automatic brakes to hold the load at any desired position for any length of time, regardless of air pressure, are now a feature of certain makes of air-motor hoists.

Lubrication of Air-Motor Hoists

When connecting up a hoist, always blow out the air hose before attaching it to the air inlet on the hoist, in order to eject any dirt or grit that otherwise might enter the hoist.

Lubrication of an air-motor hoist is important and should never be neglected. In one type lubrication is provided by enclosing the motor and gears in housings. The motor operates in a bath of medium grade oil and the gears are always partly immersed in a grease of medium consistency. In the case of the motor, an oil splasher revolves with the crank and, dipping into the oil reservoir in the bottom of the housing, keeps the entire motor lubricated. Advantage is taken of the centrifugal force of the crank to force-feed the oil to the crankpin, oil being fed from an auxiliary reservoir through the crank web to the center of the crankpin and the centrifugal force of the crank forcing it out through oil holes to the crankpin bearing. Both main valve and reverse valve are lubricated by means of felt oilers, which draw oil from the motor case and feed it to the bearing surfaces. A separating chamber takes care of any air that has become oil-carrying because of the churning action of the motor, separating the oil and returning it to its reservoir and permitting the air to escape to atmosphere through a vent cap.

With such a combination splash and force-feed system of lubrication, about all that is needed in the way of lubrication care is to renew the lubricant at regular intervals as, unless the housings leak, there will scarcely ever be need for adding make-up oil.

In another leading make of hoist an automatic lubri-

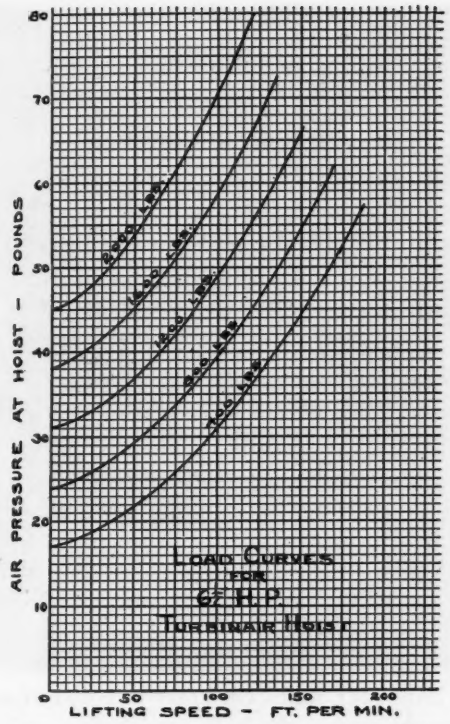


FIG. 1. RELATION OF AIR MOTOR HOIST LIFTING SPEED TO AIR PRESSURE

TABLE I. CAPACITY AND AIR CONSUMPTION FOR CYLINDER HOIST

	Inside Diameter Hoist in Inches	CAPACITY IN POUNDS AT 80 Lbs. Air	CAPACITY IN POUNDS AT 100 Lbs. Air	Cu. Ft. Free Air at *80 Lbs. Pressure Required to Lift Max. Load 1 Foot
Straight Lift=Stroke	3"	410	510	
	4"	820	1020	.542
	5"	1320	1650	.842
	6"	2000	2350	1.185
	7"	2800	3500	1.77
	8"	3730	4670	2.32
	9"	4750	5930	2.93
	10"	5690	7120	3.55
	12"	8440	10530	5:14
	14"	11650	14560	7.00
	16"	15100	18870	9.06
	18"	19300	24150	11.5
	20"	24050	30060	14.3
Geared 2 to 1 4 Foot Lift=2 Foot Stroke	4"	310	385	.271
	5"	500	630	.421
	6"	810	1020	.593
	7"	1130	1410	.885
	8"	1570	1960	1.16
	9"	2040	2550	1.465
	10"	2560	3200	1.775
	12"	3870	4830	2.57
	14"	5320	6660	3.5
	16"	7050	8810	4.53
	18"	9040	11300	5.75
	20"	11300	14140	7.15
Geared 4 to 1 4 Foot Lift=1 Foot Stroke	5"	240	300	.241
	6"	340	430	.297
	7"	480	610	.442
	8"	690	860	.58
	9"	900	1120	.733
	10"	1120	1400	.888
	12"	1680	2100	1.29
	14"	2360	2950	1.75
	16"	3190	3990	2.27
	18"	4090	5120	2.875
	20"	5120	6400	3.575
Geared 6 to 1 4 Foot Lift=8 Inch Stroke	7"	270	340	.296
	8"	380	480	.387
	9"	510	640	.488
	10"	640	800	.59
	12"	960	1210	.856
	14"	1400	1750	1.17
	16"	1880	2350	1.51
	18"	2420	3020	1.19
	20"	3020	3770	2.36

TABLE II. AIR MOTOR HOIST DATA

Load Lb.		Pressure Lb. Sq. In. 50	60	70	80
3-hp. motor 1000	A	68	94	117	137
	S	57	80	110	132
7½-hp. motor 1000	A	160	195	229	260
	S	126	157	174	161
1500	A	130	185	225	254
	S	71	117	138	150
2000	A	112	155	194	230
	S	85	64	94	124

A is air consumption cu.ft. per min.

S is rope lift speed, ft. per min.

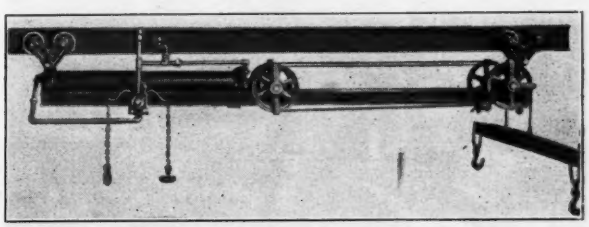


FIG. 2. BRACKET HOIST WITH DOUBLE ROPE FOR TROLLEY SUSPENSION

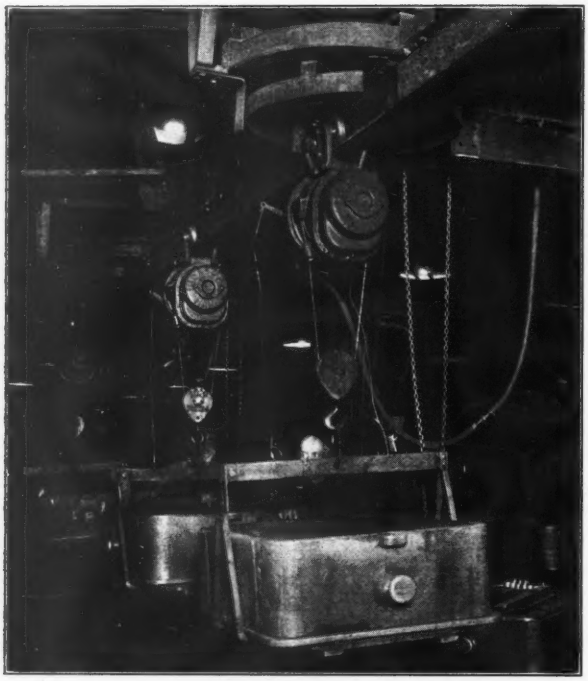


FIG. 3. INGERSOLL-RAND AIR HOIST IN FOUNDRY WORK

cator oils the rotors, feeding only when the machine is in operation and shutting off when the machine is idle or when the throttle valve is closed. This lubricator should be filled at least once daily, twice a day when the steadiness of the hoist operation warrants. A medium grade of oil that will feed from five to ten drops of oil per minute at the prevailing atmospheric temperature where the machine is being operated, is recommended. To function properly, the automatic lubricator should be set in a vertical position. Generally, the connection into which the lubricator is screwed is so made that the lubricator can be placed in an upright position regardless of how the hoist is set up. If the machine seems to receive too little oil, disconnect the lubricator from the machine, take off the cap and check the amount of oil that flows from the center hole in the bottom of the lubricator.

Other suggestions offered by the manufacturer of this hoist to avoid all trouble except what may come from normal wear after long service, are as follows:

"Oil in all points needing oil lubrication once a day.

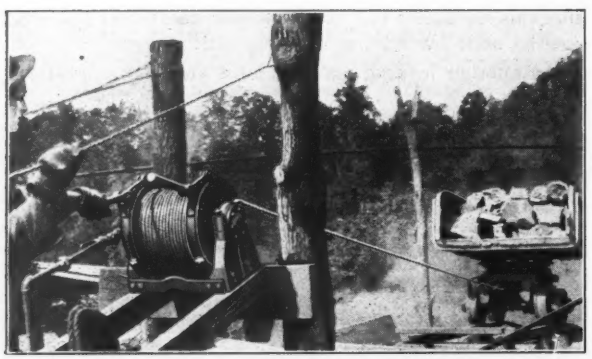


FIG. 4. TURBINAIR HOIST FOR CAR HAULAGE

TABLE III. SPEEDS AND AIR CONSUMPTION FOR AIR MOTOR JACKS

Load Tons		Air Pressure Lb.Sq.In. 50 Up	50 Down	60 Up	60 Down	70 Up	70 Down	80 Up	80 Down	90 Up	90 Down	100 Up	100 Down
0	A	56	55	62	60	74	72	84	82	98	92	108	104
	S	9	8½	9½	8½	10	9½	10½	10	10½	10½	10½	10½
10	A	50½	51	60	60	70	68	78	80	97	92	108	104
	S	6½	8½	6½	8½	8	9½	8½	10	8½	10½	9½	10½
20	A	45½	51	52½	57	68	68	74	80	88	90	108	102
	S	4½	8½	5½	9½	6	9½	6½	10	7	10½	8	10½
30	A	35	50	50	57	55	68	68	80	80	88	95	97
	S	3	8½	4	9½	4½	9½	5½	10	5½	10½	6½	10½
40	A	-	-	36	57	49	68	62	80	74	86	86	95
	S	-	-	2	9½	3	9½	4	10	4½	10½	5½	10½
50	A	-	-	-	-	48	72	58	82	57	84	77	95
	S	-	-	-	-	2	5½	2½	6	3	10½	3½	10½
75	A	-	-	-	-	-	-	-	-	50	94	68	104
	S	-	-	-	-	-	-	-	-	1½	6½	1½	6½

A = Cu.ft. free air per min.
S = Speed of ram, in. per min.

Pack the bearings for the drum, on the air inlet, with light grease every six months. See that the brake and clutch bands are in good condition, and are kept correctly adjusted. Remove the air-inlet screen, located in the coupling between the throttle valve and the air-inlet connection, at regular intervals and clean it. This screen should always be in place."

Pneumatic Jacks

In the most efficient type of pneumatic jack, the air-motor driven, the load is supported by a main lifting screw and compressed air operates a motor that furnishes the power for turning the screw. Air itself does not support the load. Lowering of the jack is accomplished by reversing the motor, so that there is no danger of dropping the load should the air fail for any reason. Average time for lifting or lowering does not exceed two minutes, consequently air consumption is relatively small, as shown in the table for different air pressures, speeds and loads.

Care and maintenance of such jacks involves nothing more than squirting a small amount of light oil into the air inlet each night after use, putting a few drops of light oil daily in the throttle valve oil hole and using a grease gun, at frequent and regular intervals, to apply grease through high-pressure fittings with which the jacks are equipped. The main screw and nut is lubricated by unscrewing three ram cap screws, removing the ram cap and using graphite grease.

Stainless steels owe their corrosion resisting properties largely to chromium, but other elements are often added to secure some desired property. For instance, zerconium sulfide for machineability, copper for salt water corrosion resistance, silicon for decreasing scaling at high temperatures, and molybdenum which helps keep the carbon in solution and increases the machineability. As a rule, they are about 10 per cent lighter than bronze.

One of the seldom mentioned but still important advantages of welded pipe is the ease of installing, insulation, and the neat appearance of the finished job. The contour of the welded joint differs little from that of the adjacent pipe, so that standard formed insulation fits well and the troublesome operation of covering the flanges is eliminated.

Moisture in Compressed Air

EFFECT ON ECONOMY, METHODS OF MOISTURE REMOVAL, MAKING THE MOISTURE HARMLESS. BY AEROCON

ALTHOUGH indispensable to human life and comfort, moisture content of normal atmospheric air offers one of the greatest obstacles to efficient utilization of compressed air. Two problems are presented; one pertaining to the broad field of commercial utilization, the other to process use in industries. Means for removing moisture from compressed air for use in special processes are generally impracticable for ordinary application, due to the expense incident to their use, and consideration of that problem lies beyond the scope of this discussion.

SATURATION OF AIR

Moisture in the atmosphere is measured as relative humidity, or the ratio of the amount of moisture actually existing at a given temperature to that which would be present for complete saturation at that temperature.

While temperature is the important factor in determining the maximum quantity of moisture which can exist in atmospheric air, as soon as the air is compressed, pressure becomes of nearly equal importance. Moisture required to saturate a given weight of air at constant pressure increases as the temperature increases. At constant temperature, the amount of moisture required to saturate a given quantity of air decreases as the pressure increases. For 100 per cent or less humidity, moisture exists as superheated vapor and no condensation is possible until the temperature is reduced below the saturation point. If it were possible to keep the relative humidity below 100 per cent throughout the entire compressed air system, there would be no moisture problem but this, unfortunately, is impossible.

COMPRESSION AFFECTS SATURATION

When saturated air is drawn into the compressor cylinder, while its pressure is increased and the volume decreased, its temperature is also increased to about 425 deg. F. at 100 lb. pressure and, in spite of the reduction in volume, its ability to absorb moisture has been increased enormously, so that the relative humidity has been greatly reduced. When discharged from the compressor cylinder, the temperature starts to decrease and, if sufficient time is available, temperature will eventually reach the saturation point corresponding to the pressure. Up to this point no condensation has been possible and the two parts have existed as a mixture of air carrying a highly superheated vapor.

As further cooling takes place, condensation continues progressively, more moisture condensing as the temperature drops. Condensate is carried along as a liquid with the stream of compressed air, unless some mechanical means are provided for separating it. The compressed air is then super-saturated, or has a relative humidity considerably over 100 per cent. Even if a mechanical separator is used, the relative humidity can be reduced only to 100 per cent for the conditions existing at the separator.

After the removal of the liquid, any further reduction in temperature will result in again creating a supersaturated state. Temperature of the surrounding atmosphere is the value to which the temperature of the compressed air is finally reduced, provided a sufficiently long time interval exists, but, under such conditions, it is impossible to deliver compressed air at the point of utilization with a relative humidity of less than 100 per cent.

EXPANSION AND SATURATION

Presence of saturated air at the point of utilization is common and makes it difficult to recover more than a small fraction of the energy which would be available, if something approaching complete expansion were practical. Most compressed air devices, therefore, utilize compressed air non-expansively, because expansion of the air would produce a reduction in temperature which would permit condensation of moisture that would freeze wherever a low temperature was encountered. The degree of expansion in the compressed air tool or motor is, therefore, limited by the relative humidity of the air at the point of utilization and the expansion ratio must be restricted to such value as fails to produce freezing temperatures.

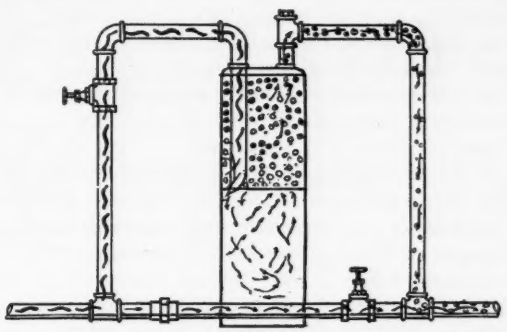


FIG. 1. LIQUID GAS IS ABSORBED BY THE AIR PASSING THROUH A TANK

It is necessary, however, to expand the compressed air at the point of exhaust to atmospheric pressure, which is accompanied by a further reduction in temperature, depending upon the characteristics of the machine. Under adverse conditions, temperatures sufficiently low to cause freezing are encountered and, unless special precautions are taken, the exhaust port is blocked, resulting in complete stoppage of the machine.

REMOVING MOISTURE

Various devices have been developed to alleviate this condition. Heretofore, they have been limited to two general types, temperature changers and mechanical separators. Operation of mechanical separators is limited to converting super-saturated air to air saturated at the temperature existing within the separator. They can exert no influence over further condensation of

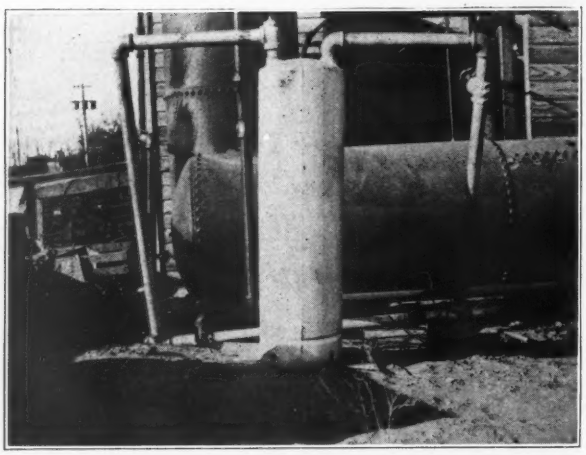


FIG. 2. FOR SYSTEM PROTECTION THE GAS TANK IS PLACED NEAR THE RECEIVER

moisture in the compressed air, if lower temperature is encountered after the air has left the separator. Mechanical separators will solve the problem, except when air is used expansively, if they can be installed at a point in the system where the lowest temperature will be encountered, a requirement which is generally impossible to meet. Moreover, if temperature at the separator is below the freezing point, the liquid that collects within it will freeze and soon render the separator inoperative.

Aftercoolers are generally some simple form of heat-exchanger utilizing water as the cooling agent, their effectiveness being limited by the temperature of the cooling water. They deliver saturated air at that temperature. If further reduction in temperature is encountered, there will be further condensation of moisture. In order that an aftercooler be 100 per cent effective, it would be necessary for it to cool the compressed air to a temperature below the lowest temperature existing in the compressed air system, which is generally made impossible by other considerations.

Use of a refrigerant at once suggests itself, as by its use considerably lower temperature could be attained than with circulating water. Over half the power required to supply the refrigerant is, however, wasted, on account of reducing the weight of dry air to the low temperature, so that the method is impractical except for process work.

Air Reheating

If saturated air is heated, the relative humidity of the heated air is reduced to that corresponding to the final temperature of the air as it is discharged from the heater. This temperature is generally limited by considerations of lubrication and safety. But reheating solves the problem, provided it is possible to heat the air to such a temperature that saturation temperature will not be reached until air is discharged completely from the compressed air motor. Where this is impossible, the reheater is but a partial solution of the problem. Wherever it is practical to use it, reheating is useful but, unfortunately, it is not always possible to install such equipment and a reheater invariably represents additional expense for attendance and fuel.

Each of the above methods has a distinct field of practical application and in combination they afford a practical solution to the moisture problem but within rather narrow limits. It is the writer's intention, not to condemn these devices as useless but rather to define their limitations. The discussion, however, emphasizes the desirability of additional means for coping with this exasperating problem.

Rendering Moisture Harmless

Years ago, investigators realized that the ideal solution of this problem was to find a substance which could be injected into and carried along by the stream of compressed air, so as to be present at every point in the system where a temperature was encountered sufficiently low to cause condensation. As soon as moisture was precipitated, such a substance should immediately mix with it to make the freezing temperature of the solution lower than any subsequent temperature encountered. For years, commercial alcohol was the only substance available and was used with varying success in coping with frosting problems.

Most commonly it was injected into the compressed air through a lubricator of suitable design. Another method of application used by some was to place it in the bottom of the air receiver but this practice is in direct violation of Underwriters' regulations in most

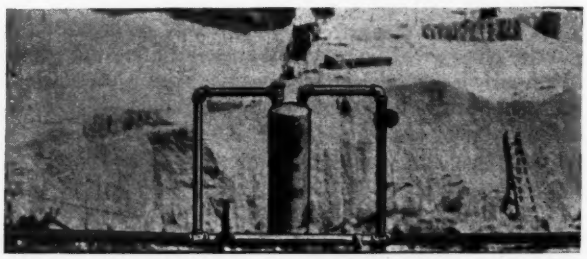


FIG. 3. PROTECTION FOR ANY BRANCH IS HAD BY CONNECTING IN A LOCAL TANK

states. A third method was to evaporate it into the intake of the air compressor, compressing it with the air. These last two methods introduce a danger from explosion which is to be avoided. Other objections to the use of alcohol are the difficulty of controlling the mixture, resulting in excessive use of the alcohol; also it has a detrimental effect on packing and lubrication; finally, when used in a confined place in sufficient quantities to cope with the freezing problem, it is irritating to the eyes and mucous membranes.

Special Gas Treatment

Several years ago, efforts were directed towards finding a substitute for alcohol which would be safe, economical, not harmful to machine parts nor detrimental to health. At the same time it was necessary to adhere to the principle of a solution, so as to preserve the desirable feature of complete protection against freezing at any point in the compressed air system where low temperatures might exist, whether from atmospheric changes or the expansion of the air itself. Tanner-Gas, now available to meet these exacting specifications, is a liquid of low volatility.

In practice, the stream of compressed air is allowed to blow over the exposed surface of the gas, which about half fills the auxiliary tank used for this purpose, Fig. 1.

By agitating the surface, the compressed air stimulates the evaporation of the liquid so that the stream of compressed air is thoroughly impregnated. As the density of the gas is about the same as that of compressed air, it is carried along by turbulent flow, in a well mixed condition. Wherever a temperature is encountered sufficiently low to cause condensation, the gas in its finely diffused state is brought into intimate association with the drops of moisture and immediately goes into solution.

The resulting solution has a freezing temperature of 70 deg. below zero when saturated. The moisture is not removed but is rendered harmless for most applications, by lowering its freezing point. In those cases where it is necessary to eliminate liquid from the compressed air before it is used, a mechanical separator can be used, as the gassed liquid in the separator will not freeze. In most applications, however, the percentage of moisture in the compressed air is so slight that it can be carried through the compressed air machine without injury and be ejected with the exhaust. Gas present in the air, as it passes through the tool, mixes immediately with any additional moisture which may be precipitated as a result of further reduction in temperature due to expansion.

As mentioned above, the gas is utilized in a tank which is provided with a bypass so that, when no antifreeze material is required, economy can be secured by bypassing the tank. Where the entire compressed air system is to be protected, a large tank located close to the air receiver, Fig. 2, is to be recommended. In this case, air is discharged from the compressor into the receiver, thence passes through the tank. In cases where freezing troubles are experienced on but a few branches of a complicated air system, smaller tanks are recommended for connection into these branches, Fig. 3. Under most conditions, complete protection is afforded by the use of about 1 gal. of Tanner-Gas for each 500,000 cu. ft. of free air used, which indicates a nominal operating cost. Further economy is obtained by the bypass which stops the use of gas when weather or operating conditions render it unnecessary.

Possibilities in compressed air economy seem to lie in increased expansion ratios by the simple expedient of using this gas to prevent freezing. Finally, opportunities seem possible for utilizing the refrigerating characteristics of completely expanded compressed air, accompanied by the utilization of a larger percentage of the total energy possessed by the air.

Cost Record System for Small Plant

PERFORMANCE AND COST RECORD SYSTEM DEVELOPED BY THE AUTHOR IS ADAPTABLE FOR ANY SMALL POWER PLANT. BY LAWRENCE B. BROWN*

SO SIMPLE AND inexpensive, although so effective, has been the permanent record system which is used in our power plant, that I am offering and recommending it to my fellow engineers.

We operate 24 hr. a day, seven days a week in three watches, 11 to 7, 7 to 3 and 3 to 11. Under each of these watch headings, Fig. 1, the cubic feet of gas fired and pounds of steam generated are entered on the left-hand page, the boiler and engine performance being figured out and a card made out for each watch. The right-hand page is used to record the 24-hr. run.

*Chief Engineer, Jonathan Club, Los Angeles, Calif.

Boiler and engine-generator log sheets are attached to this sheet and with the help of these log sheets, data are compiled and entered in the permanent record books. Yellow cards, Fig. 4, give information to watch engineers which creates considerable rivalry among them. One card is filled out with average data for the entire 24-hr. period.

We fire natural gas and, as fuel oil is still the largest fuel supply in our section, I am comparing the two fuels on a B.t.u. basis. The fuel oil we burned formerly had a heating value of 18,500 B.t.u. per lb. while natural gas here averages 1100 B.t.u. per cu. ft. Seventeen cubic

Record Book 1
DAILY BOILER PERFORMANCE — MONTH

Date	11 - 7		7 - 3		3 - 11																
	Cubic Feet Gas Fired	Pounds Steam	Cubic Feet Gas Fired	Pounds Steam	Cubic Feet Gas Fired	Pounds Steam	Total cu.ft. Gas Fired 24 hours	Total A.C. Light & Power Generated	Gallons Oil	Fuel Cost	Boiler Number	Total Steam Hours	Heat System Hours	Total Pounds Steam Generated Flow Meter	Gas	Comparison of Oil	Fuel Cost Per M lb. Steam	Total Cost Per M lb. Steam	24 Hour Boiler Efficiency	Average Hourly B. hp.
1st of month to 30th or 31st																				

Comparison

Monthly Summary

Total kw. Generated =
Total cu.ft. Gas Fired =
Total Fuel Cost =
Daily Average cu.ft. Gas =
Daily Average Fuel Cost =
Total Pounds Steam Generated =

Cutler-Hammer Book

Average Evap. for Month =
Average hourly b.h.p. for Month =
Average Boiler Efficiency for Month =
Total Cost Per M lb. Steam for Month =
Fuel Cost Per M lb. Steam for Month =
Cost per kw. to Generate =

Record Book 2
DAILY ENGINE GENERATOR PERFORMANCE

Date	Total Pounds Live Steam To Engine	Total kw. Generated Light	Total kw. Generated Power	Stand-by Charge	Depreciation	Lubricating Oils Cylinder	Lubricating Oils Engine	Total Hours Run	Total Cost of Kilowatts if Purchased	Days Savings	Saving To Date This Month	Pounds of Exhaust Steam Used	Credit for Exhaust Steam	Purchased Standby Kilowatts Kw. Cost	Cost per kw. if Making	Cost per kw. if Purchasing	Saving per Kilowatt

Monthly Summary

Total Pounds Live Steam =
Total Pounds Exh. Steam =
Total kw. Generated - Light =
Total kw. Generated - Power =

Charges

Standby Chg. =
Depreciation =
Lub. Oil =
Purchased kw. =

Total Steam Cost =
Total Charges =

Total Engine Operating Cost =
Credit for Exh. =

Final Engine Cost =

FIG. 1. DOUBLE PAGE FORM IN RECORD BOOK NO. 1 FORMS BASIS FOR SUMMARIES

DAILY ENGINE GENERATOR REPORT — Date

Watch	Steam Flow Meter Reading	Watt-Hour Meter Reading	Total Lbs. Steam Used	Total Kilowatts Generated	Lbs. Steam Used from Exhaust	Credit for Exhaust Steam Used	Cost per Kilowatt	Purchased Kilowatts: Kilowatts	Purchased Kilowatts: Cost	Kilowatts Steam: Kilowatts	Kilowatts Steam: Cost
11-7											
7-3											
3-11											
Totals											

MAKING KILOWATTS		PURCHASING KILOWATTS		SURPLUS USED		REMARKS	
Steam Cost		Purchased Cost		Engine Oil			
Standby Charge				Cylinder Oil			
Lubricating Oil		Steve Kilowatts		Waste, etc			
Depreciation				Packing			
Supplies				Repairs			
Repairs		COMPARISON					
Purchased K. W							
		Purchased Cost		RUNNING TIME			
Credit for Exhaust		Making Cost					
Steve Kilowatts				Start			
				Stop		ENGINEERS	
				Total		11-7	
		Savings				7-3	
						3-11	
Total Cost		Savings to date					

FIG. 2. DAILY ENGINE GENERATOR REPORT

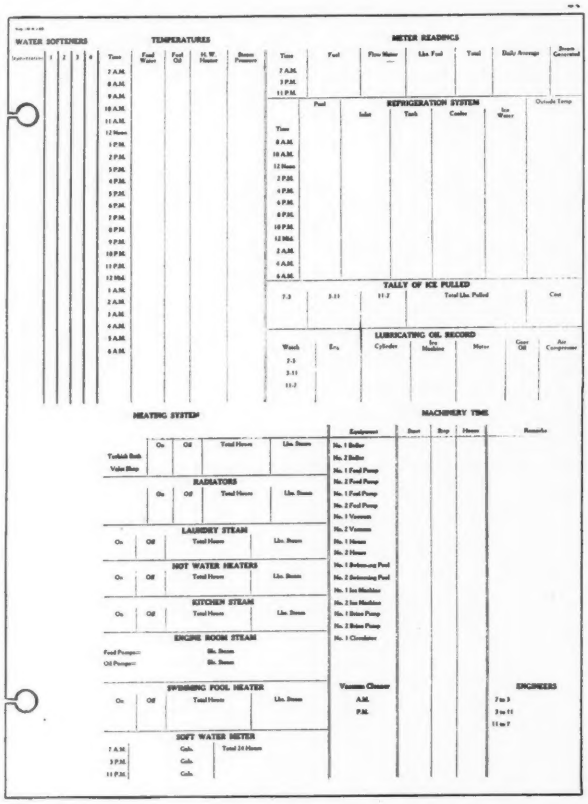


FIG. 3. PLANT EQUIPMENT DAILY LOG SHEET

24 Hour Average Monday 3/17/30
1742 KW of A.C. Light generated
LBS.-STEAM- 104,160# Steam = Average 4345# Per Hr.
GAS- 120,773 Cu Feet Gas = 7430# Oil = 993 Gal oil
EVAP.- 14.5# Water Evap per 1000 Cu Feet Gas fired.
or Comparison of Gas to oil = 14# Water per 1# oil.
B.H.P.= 136 - Boile Horsepower - Hourly Average
EFF.= 78% - Boiler Efficiency - Average 24 Hrs.
COST= $.12 = Fuel only = $.35 Total cost Per M#
PRESS= 150#
COM= 88% Average Hourly For 24 Hrs.
Simple & the Cost for 24 Hour Average.

FIG. 4. CARDS USED FOR GUIDANCE OF WATCH ENGINEERS, STANDARD 4 BY 6 IN. SIZE

ENGINEER'S DAILY COMPARATIVE REPORT

Date	COMPARISON DATES: Present year	Last year
Total steaming hours		
Total heating system hours		
Pounds of steam generated in 24 hours		
Pounds of fuel oil burned in 24 hours		
Cost of 24 hours' operation		
Average hourly boiler horsepower		
Evaporation, pounds of water per 1 pound fuel oil (Tested Gas)		
Boiler efficiency		
Steam pressure, pounds		
Cost fuel oil per barrel or Gas Meu Test	All Fuel	All Fuel
Cost to make 1,000 pounds steam		
Average steam per hours, pounds		
Total kilowatts, 24 hours		
Cost per kilowatt		
Total cubic feet water consumed 24 hours		
Total cubic feet gas consumed 24 hours		
Pounds of ice issued		
	OUTSIDE TEMPERATURES	
HIGH		
LOW		

feet of gas will have, therefore, 18,700 B.t.u. and be equivalent to almost 1 lb. of oil. Dividing 17 cu. ft. into total gas therefore equals equivalent pounds of oil. Dividing 7.5 into total pounds of oil equals gallons of oil and total cubic feet of gas fired into total pounds of steam generated equals evaporation of pounds of water per cubic foot of gas fired.

Record book No. 3 contains data on the electric light and power loads. Meters 1, 2 and 3 are on the utility company's standby line, as our engine generates all our alternating-current lighting and a small part of our power. These meters register only when our engine is shut down. The total light consumption reading is taken from the watt-hour meter on the engine switchboard. The small amount of power generated is taken also from a meter on the engine switchboard.

Meter No. 4 is a sub-meter used to meter electricity consumed by the stores. Each store also has an independent meter in the basement. Meters No. 5 and 6 are for alternating current. Meters No. 7 and 8 are for

REPORT NO. 1
THE JONATHAN CLUB ENGINE ROOM
JANUARY, 1930

Kilowatts used during month—Light..43,620 kw.—From engine
Kilowatts used during month—Power. 8,760 kw. " "
Kilowatts used during month—Total..52,380 kw. " "

ENGINE GENERATOR PERFORMANCE

Total lb. live steam to engine—
1,972,800 lb. at $0.18 ..... $361.03
Total lb. exhaust steam used—
1,511,000 lb. at $0.18 ..... Credit 276.51

Live steam cost	361.03	Purchased cost kw. Light at 2c	872.40
Standby charge	55.00	Purchased cost kw. Power at 1.1c	96.36
Depreciation	66.00	Total	$968.76
Lubricating oils	13.32	Total cost of purchased kw.	968.76
Supplies	1.20	Total cost of making kw.	225.27
Purchased kw.—110	5.23		$743.49
Operating Cost	$501.78	Stores —2693 kw.	94.34
Total engine operating cost	501.78	Grand Total Savings	$837.83
Credit for exhaust steam	276.51		
Final Cost	$225.27		

Cost per kw.—$0.0043.

direct-current power. By means of the readings of the above meters, data is obtained for the daily load graphic charts for power, light, gas, water and ice consumed. Form 3B is for kitchen gas and main water records.

Electric lamp daily or individual issue record is made in Record book No. 4, a line being used for each issue. In the monthly summary, Book No. 5, a line is used each day for daily totals for each size of the lamp.

Monthly reports are made up with original and carbon copies, the former going to the manager's office while the latter remains in the chief engineer's file.

Report No. 1 is a comparison which shows the savings made over purchased alternating current.

Report No. 2 is a comparison between operation, when all current was purchased in 1929 and operation with the Unaflow engine during the corresponding month in 1930. This report for the year 1929 includes the entire fuel cost for supplying all heating such as steam heat, hot water heating, kitchen, laundry, valet shop and swimming pool heating and for 1930, steam for the engine is included with the uses named for the previous year.

REPORT NO. 2

January, 1929 against 1930

January, 1929		January, 1930	
Fuel cost—18½c per M. cu. ft. (total fuel, 3,294,431 cu. ft.)	609.47	Fuel cost—15c per M. cu. ft. (total fuel, 3,878,359)	581.74
Total light—38,730 kw.	774.60	43,620 kw.	
Total cost	1,384.07	Charges, standby, etc..	140.75
		Total cost	722.49
4,890 kw. more in 1930		Savings	661.58
		4,890 × 0.02	$97.80
		Total savings	$759.38

Power—1930 kw. used ..... 8,260 kw.

8,260 kw. of power if purchased at $0.011	90.80
8,260 kw. of power cost to make 0.0043	35.52
Saving on purchased power	$55.28
Total saving over 1929—all steam and light	814.66

(Figuring same fuel rate 1929 as 1930.)

3,294,431 cu. ft. at $0.15 per M. cu. ft.... 494.17

At $0.18½ rate	609.47	Fuel rate difference	115.30
At $0.15 rate	494.17		
	$115.30		$699.36

If 1929 at $0.15 fuel rate Grand Total Savings $699.36

Record Book 12

First Half of Book - this form

Boiler & Engine Rooms — Lubricating Oils and Greases Purchased																							
Engine Oil			Cylinder Oil			Ice Machine Oil			Motor Oil			Gun Grease			Gear Oil								
Date	Gallons	Cost	Date	Gallons	Cost	Date	Gallons	Cost	Date	Gallons	Cost	Date	Pounds	Cost	Date	Pounds	Cost						

Record Book 12a

Boiler & Engine Rooms — Supplies & Replacement or New Equipment							
Date	Type Supplies or Equipment	Quantity	Cost each	Per cent discount	Total Cost	Stock Replace	

Record Book 13

Boiler & Engine Room Supplies Expended — Lubricating Oils												
11 - 7 Watch			7 - 3 Watch			3 - 11 Watch			24 hr. Consumption			
Date	Type Oil	Gallons	Date	Type Oil	Gallons	Date	Type Oil	Gallons	Date	Type Oil	Gallons	Cost

Note: Above form 1st half of book

Record Book 13a

Boiler & Engine Rooms — Supplies & Replacement or New Equipment Expended						
Date	Type Supplies or Equipment used	For Shot use	Quantity	Cost Each	Total Cost	Remarks

Note: Above form last half of book

FIG. 7. FORMS USED FOR PURCHASES AND EXPENDITURES

Record Book 3-A

Meter Reading — Month							Daily Consumption — Month					
Date	No.1 Meter A.C. Light Bldg 220 x 60	No.2 Meter A.C. Light Bldg 220 x 80	No. 3 Meter A.C. Light Garage 220 x 30	No. 4 Meter A. C. Light Sub Stores 220 x 20	No. 5 Meter A. C. Power Bldg 220 x 200	No.6 Meter A.C. Power Garage 220 x 60	No.7 Meter D.C. Power Bldg Vent Fans 220 x 60	No.8 Met r D.C. Power Garage Vent Fans 220 x 20	Date	No. 1 Meter Bldg	No.2 Meter Bldg	No.3 Meter Garage	No.4 Meter Sub Stores

Left page — Right page

Record Book 3-B

Meter Readings — Consumption — Month							
Date	Water Meter	Gas Meter No.1	Gas Meter No.2	Date	Water	Gas No.1 Kitchen	Gas No.1 Bakery & Kitchen

One page only

Record Book 4

Electric Lamps Issued								
Date	Location	Order or Replace	Watts	Type	Dept.	Number	Discount per cent price	Total cost

Record Book 5

Monthly Summary - Electric Lamps Issued & Purchased — Month							
Purchased Number Cost	Watts	Type	Number	Watts	Type	Discount	Total Cost

Record Book 6

Electrical Supplies & Equipment Purchased					
Date	Type - Supplies or Equipment	Catalog Number	Quantity	Cost Each	Total Cost

One page only

Record Book 7

Mechanical Supplies - Fittings & Valves Purchased					
Date	Type - Supplies or Fittings	Quantity	Cost each	Per cent Discount	Total Cost

Record Book 8

Maintenance Supplies - Carpentry-Painter-Plumber Purchased					
Date	Type - Supplies	Quantity	Cost each	Per cent Discount	Total Cost

Record books 9,10 and 11 all take the below form

Electrical / Mechanical / Maintenance) Each Book is headed and numbered for Type Supplies

Date	Location used or Dept. Issued to	Repair Order Number	Cost each	Total Cost

FIG. 6. VARIOUS FORMS USED FOR SPECIAL RECORDS

Report No. 3 is on boiler and refrigeration plant performance and includes costs of operation and financial gains made, the club being charged at the rate of 2 per cent of the operating cost.

CHIEF ENGINEER'S MONTHLY REPORT FOR ....., 1930

STEAM PLANT	REFRIGERATION PLANT
Total lb. steam generated = ...	Power and light = ...
Average evaporation for month = ...	Salaries = ...
Average hourly b.hp. for month = ...	Water = ...
Average boiler efficiency per month = ...	Depreciation = ...
Total cu. ft. gas fired = ...	Supplies = ...
Total fuel cost = ...	Supervision (C.E.) = ...
Salaries (engineers) = ...	Operating cost = ...
Water and Elec. = ...	Club charges
Depreciation = ...	Cubed ice = ...lb.
Supplies = ...	at $0.20 per C. = ...
Supervision (C.E.) = ...	Crushed ice = ...lb.
Total operating cost = ...	at $0.20 per C. = ...
Revenue on .... lb. steam at .... M. lb. = ...	Tons Refg. = ...t.
Operating cost = ...	at $0.50 ton = ...
In favor of plant = ...	Store Shop Ref. = ...t.
Fuel cost per M. lb. steam = ...	at $0.50 ton = ...
All cost per M. lb. steam = ...	D. & G. Store = ...lb.
Total kw. generated = ...	at $0.40 per C. = ...
Cost to make per kw. = ...	Cutting and chipping = ...
	Revenue = ...
	Operating cost = ...
	In favor of plant = ...
	Cost per ton refrigeration = ...
	Steam plant profit = ...
	Refrigeration plant profit = ...
	Profit in favor of entire plant = ...

Record Books 12 and 13 are used for all supplies and equipment for the engine and boiler rooms, the former being for supplies purchased; the latter for supplies expended. All items are entered on classified sheets as indicated in Fig. 7. Department maintenance is kept separate from building maintenance and each department is charged a prorated percentage of service cost.

Record Book No. 14 is a log book in which descriptions of all changes, repairs and replacements are entered consecutively according to date. At the end of each month, all total costs of supplies, replacements and new equipment are added to the fuel, water and labor costs to arrive at the total production cost per thousand pounds of steam.

Effect of Excess Air on Boiler Efficiency

Furnace, Volume and Shape, Type of Coal and Combustion Rate Determine Efficient Operation

IN ORDER TO burn coal completely, it is necessary to bring each molecule of carbon (or combustible) into contact with a molecule or more of oxygen. With an infinitely large furnace volume, plenty of time, and with some provision for turbulence, each molecule of the oxygen supplied could be made effective and the coal burned with the amount of air theoretically necessary. In actual practice, it is not practical to build such large furnaces nor to take the time to mix the gases thoroughly.

For this reason, it is necessary to supply more air than is theoretically necessary. If this excess air is not supplied, a large part of the heat value of the coal is lost either as CO or carbon up the stack or to the ash pit. As shown by the dotted line at the bottom of Fig. 1, the incomplete combustion loss of about 10 per cent with 5 per cent excess air can be reduced to 2 per cent with 30 per cent excess air or to a fraction of a per cent with 60 per cent excess air.

Introducing excess air in this manner does, however, bring in a new loss which increases directly with

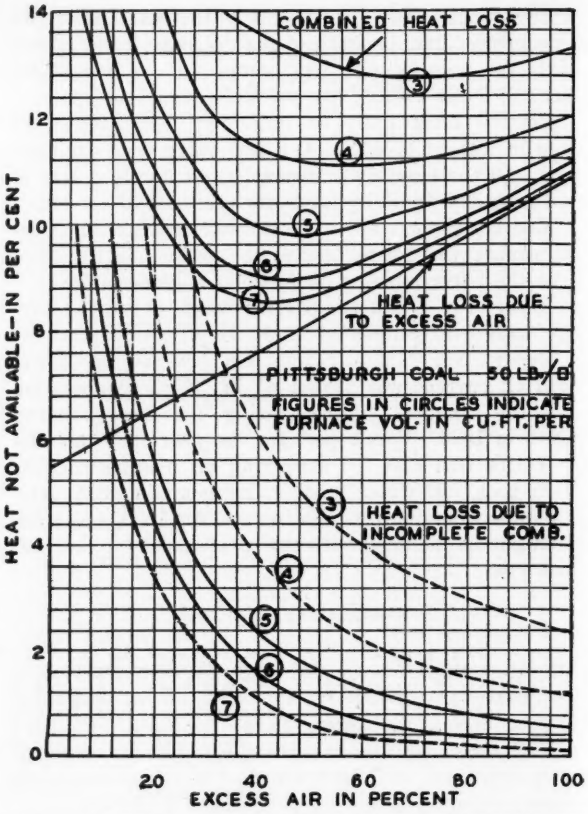


FIG. 1. EFFECT OF INCREASING FURNACE VOLUME ON HEAT LOSS WITH SAME COAL AND RATE OF COMBUSTION

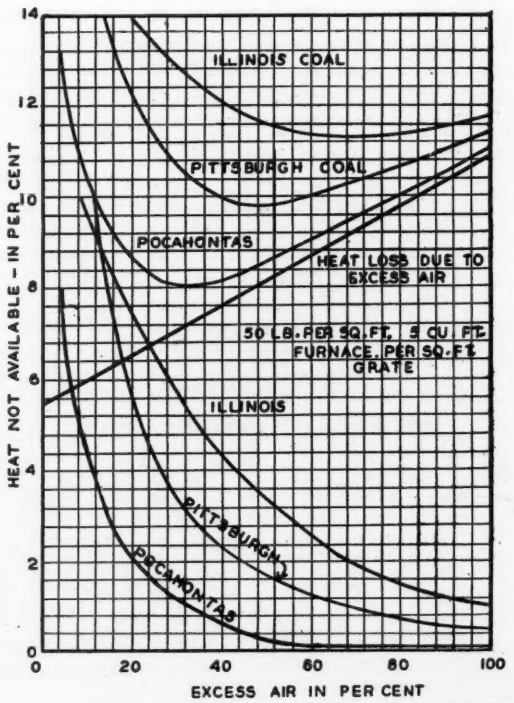


FIG. 2. FOR THE SAME RATE OF COMBUSTION AND FURNACE VOLUME, DIFFERENT COALS REQUIRE DIFFERENT AMOUNTS OF EXCESS AIR

the excess air used. This loss is shown by the straight diagonal line in the middle of Fig. 1. The engineer is faced with the difficult problem of balancing the two so that the combined losses are at a minimum. The method of doing this is shown by the chart mentioned. Dotted curved lines at the bottom show the heat loss due to incomplete combustion for various furnace sizes ranging from 3 to 7 cu. ft. of furnace volume per square foot of grate area. Adding these losses to the excess air loss gives the series of curves at the top of the figure. The combined losses decrease gradually to a minimum point and then increase. The low point on the curve shows the best operating condition.

This point depends upon a number of factors and varies widely so that the CO_2 alone is not a measure of operating efficiency. As shown by Fig. 1, the best operating point with a small furnace (3 cu. ft. per square foot of grate area), is about 66 per cent excess air while for a large furnace (7 cu. ft. per square foot of grate area), only about 41 per cent excess air is desirable. These points correspond roughly to 10.75 and 13 per cent CO_2.

Furthermore these curves show why a large furnace is much more sensitive than a small one. With the 3 cu. ft. per square foot of grate area furnace, excess air can be varied from 50 to 100 per cent (9 to 12 per cent CO_2) without affecting the efficiency more than about ½ per cent. With a large furnace (7 cu. ft. per square foot of grate surface), excess air must be kept between about 30 to 60 per cent (14 to 11.5 per cent CO_2) to keep within the same margin. Of course, furnace shape as well as volume is important so that the curves shown cannot arbitrarily be applied to any furnace that shows the same furnace volume to grate area ratio.

Nor can the type of coal be neglected. Some coals burn with a long flame and need a large furnace volume, others have a short flame and can be burned successfully with small furnaces. This is effectively shown by Fig. 2 drawn for three kinds of coal, Pocahontas, Pittsburgh and Illinois, for the same rate of combustion and same furnace volume, i.e., 50 lb. of coal per square foot and 5 cu. ft. of furnace volume per square foot of grate area. Under these conditions Illinois coal shows the best efficiency at about 70 per cent excess air (10.75 per cent CO_2), Pittsburgh coal at 45 per cent excess air (12.5 per cent CO_2) and Pocahontas coal at about 25 per cent excess air (14 per cent CO_2).

The important point to be noted is that different furnaces and different fuels require different percentages of excess air to give the best results. No one definite percentage of CO_2 will give the best results in every furnace burning every kind of coal at any rate of combustion. Sometimes high CO_2 is desirable and sometimes low CO_2. The only general conclusion that can be drawn is that the lower the volatile in the coal, the larger the furnace volume and the lower the rate of combustion the more definite the necessity for accurate excess air control.

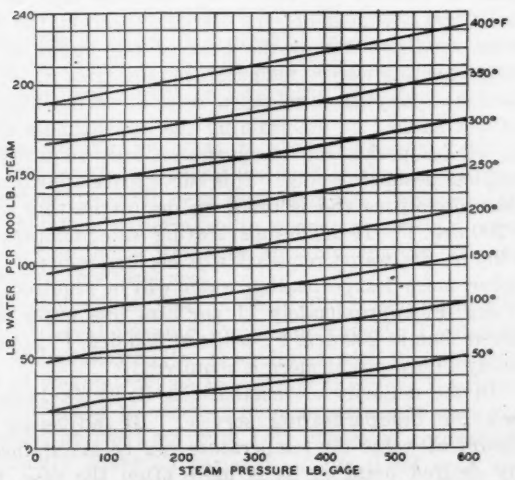
Types and Operation of Desuperheaters

CLOSED, CARTRIDGE AND SPRAY TYPES DEVELOPED TO MEET REQUIREMENTS BROUGHT ABOUT BY MODERN POWER PLANT PRACTICE

OF RECENT YEARS, desuperheaters have been developed to fulfill a very definite demand brought about by the almost universal use of high temperature superheated steam in the power plant. One of the first demands for equipment of this kind came from the addition of high pressure and high temperature sections to existing stations. A tie-in between the old and new station is desirable. By throttling high pressure, high temperature steam, a temperature too high to be used in old equipment results and a desuperheater will reduce this temperature to any desired point.

Another demand is in connection with heating systems normally using low-pressure steam from the turbine exhaust or extraction point. In cases of this kind, emergency service with the reducing valve is always provided and a desuperheater is necessary to avoid strain and stress which would be developed in the piping by the highly superheated steam coming from the reducing valve. They also have wide application for industrial plant work, for removing the superheat from low pressure steam, for process work when superheat is undesirable and in industries where comparatively small quantities of saturated steam are necessary but where it is advantageous to generate all the steam in one plant rather than operate separate saturated steam boilers.

Desuperheaters in general are divided into three types: the closed, or non-contact type; the spray type; and the cartridge, or surface absorption type. The closed type desuperheater is essentially a closed feedwater heater with the steam to be desuperheated inside the tubes and the water outside. Heat removed when desuperheating the steam generates additional saturated steam which is taken from the top of shell and introduced into the steam line on the outlet side of the desuperheater.



THEORETICAL QUANTITY OF WATER REQUIRED FOR COMPLETE DESUPERHEATING WITH A WATER TEMPERATURE OF 200 DEG. F.

The spray type desuperheater consists of a spray nozzle located in the pipe and closely followed by a steam separator for removing excess water from the steam. A spray nozzle introduces the water into the steam in atomized form and the superheat in the steam is used in evaporating some of the spray water.

Cartridge type desuperheaters consist of a body with removable cartridge of some material like woven wire. The spray is injected through nozzles and trickles downward through woven wire mesh, while the steam passes through the cartridge and comes into intimate contact with the drops of water on the wet surface of the wires.

Water Required

Regardless of type of desuperheater, the principle of operation is in general the same. It involves the evaporation of a quantity of water equivalent in heat content to the reduction of superheat in the incoming steam. The additional quantity of steam resulting from evaporation of desuperheated water in sufficient quantity to compensate for the destroyed superheat passes through the outlet nozzle of the desuperheater.

Heat to be removed per pound of steam is equal to total heat at the initial condition, minus the total heat at the final condition. For example, if it is desired to remove the superheat from steam at 200 lb. ga. 300 deg. F. superheat, it will be necessary to remove the difference between 1359.1 B.t.u. and 1199.2 B.t.u., or 159.9 B.t.u. Water is used as the cooling medium and the heat absorbed per pound of water is that required to raise the water from the initial temperature to steam at the final steam condition. Assuming desuperheating water at 200 deg. F., heat absorbed per pound of water in the foregoing example will be 1199.2 minus 169 (200 minus 32) or 1031.2 B.t.u. The number of pounds of desuperheating water per 1000 lb. of steam equals 1000 times 159.9 divided by 1031.2, or 155. This is the amount of water required theoretically to remove the superheat completely. The formula is:

$$W = [Q\ (H_1 - H_2)] \div (H_2 - q)$$

in which W is the number of pounds of water theoretically required for desuperheating; Q the quantity of steam in pounds per hour; H_1 the total heat at the initial steam condition; H_2 the total heat at the final steam condition and q the heat of the liquid of the desuperheating water (temperature in degrees F. — 32). The accompanying chart taken from Powerfax provides a quick method of determining the approximate quantity of desuperheating water theoretically required for complete desuperheating. This curve gives approximate water quantities and is based on desuperheating water at 200 deg. F. If the desuperheating water temperature is lower, the water required will be less, while if it is higher, more desuperheating water will be required. At 70 deg. F. approximately 11 per cent less water is required than at 200 deg. F., while at 350 deg. F. approximately 17.5 per cent more is required.

In the majority of installations, boiler feedwater is used for desuperheating service. By adjusting the amount of water the temperature can be maintained at any desired point or as is more often the case, total desuperheating can be accomplished so that dry saturated steam leaves the desuperheater. The amount of steam used depends, of course, upon the load and although hand control is satisfactory where the steam flow is fairly uniform and conditions are not particularly exacting, automatic control is desirable. Control equipment of this kind maintains the water flow in proper portion to the steam flow and final steam temperature can be maintained between plus or minus 5 deg. in carefully designed installations.

Gas Used for Electric Shock Treatment

Announcement was recently made that the cure of numerous serious cases of pneumonia in which physicians of the electric companies of the New York Edison System coöperated with attending physicians in administering a treatment based on procedure for resuscitation from electric shock. The treatment is the administration by inhalation of a mixture of oxygen and carbon dioxide. This so abates the congestion of the lungs that the patient gradually becomes able to breathe normally.

"This treatment is part of our present procedure for taking care of victims of electric shock," said Matthew S. Sloan, president of the New York Edison System. "Its application to pneumonia has been carefully tested. The results obtained have impelled us to lay our experience before the medical profession and the public.

"About a year ago, our supervising physician gave a talk before the Kings County Medical Society in which he described our resuscitation practice, saying that one phase of it—inhalation—was indicated for pneumonia cases. A month or so later, a Brooklyn physician who was treating a desperate case of pneumonia thought that the part of our procedure which dealt with inhalation, as described in our physician's talk, might be effective in the case he was treating. He called on us for help. We gladly supplied him our facilities. A speedy and complete cure was effected.

"Since then we have been called on by physicians to furnish facilities in similar cases. Our physicians now have a record of 127 cases in which the treatment has been used. Of these, 42 were beyond recovery when our people were called in. Of the remaining 85 where there seemed a chance of recovery, however slight, 70 patients were cured and only 15 died. In treating our own employes for pneumonia, the physicians have been completely successful as 5 employes were treated and all were cured.

"The treatment is simple and embodies no secrets. It consists in the administration of a suitable mixture of oxygen and carbon dioxide. It has been advocated by Dr. Yandell Henderson of the Medical School of Yale University for several years. This is the first time, however, that it has been tried in an organized way and in so many cases."

In connection with the use of Diesel engines, the German Tar Products Sales Union and its affiliated associations have decided to organize a prize competition for processes for recovering a fuel oil from German coal suitable for use in Diesel engines and particularly in small power units of this type. Three prizes, of respectively, $2500, $1250 and $750 are being offered in connection with the competition, full particulars of which can be obtained from the Verkaufsvereinigung fur Teererzeugnisse, Essen, Germany.

Viscose Co. Extends Plant at Parkersburg

Pulverized Coal Burning Selected to Burn Low Grade Local Fuel, After Making Preliminary Tests at Other Plants. By Harry A. Kuljian*

IN 1926 THE VISCOSE CO. built and placed in operation at Parkersburg, W. Va., a new factory for the manufacture of rayon by the Viscose process. This factory was provided with its own power plant for serving it with all the steam, water and electricity required for the manufacturing processes. Since the completion of this plant in 1926, the demand for rayon has grown to such an increasing extent that it has become necessary to enlarge the power plant serving it. These enlargements are the subject of this article. At present the output of the factory is approximately 1,000,000 lb. of rayon a month.

After this expansion, the capacity of this plant will be almost 255 per cent of its original capacity and the increased demand for electric power and steam will be obviously in the same proportion. This particular process of manufacturing rayon must have an absolutely uninterrupted supply of electrical power free from severe surges or voltage fluctuations. This is one of the principal reasons why the Viscose Co. generates its own electrical power.

Requirements for Expansion

At the present time, the steam demand of the factory is 220,000 lb. per hr. and the electrical demand 5000 kw. When the plant is enlarged, the steam demand will be 480,000 lb. per hr. and the electrical demand 11,250 kw. When the plant was originally designed, the turbine and boiler rooms were laid out to accommodate the anticipated expansion.

*Engineer, The Viscose Company, Marcus Hook, Pa.

Four boilers are installed in the present boiler room. These are each 1000-hp. box header boilers operating at 75,000 lb. steam per hr. Three units supply the maximum steam required, the fourth being installed as a standby.

Type of Fuel

These four boilers were operated by underfeed stokers using high grade coal from distant mines. Coal from distant mines was decided upon because local coal is high in sulphur, ash and volatile matter, and the repair and maintenance costs of stoker parts as well as the sacrifice in boiler ratings which would be occasioned by the use of low grade coal were sufficient justification for the increased cost of importing coal from distant mines.

In extending this plant, it was thought that perhaps local low grade coal might be used if the proper type of combustion equipment was installed. Experiments were therefore undertaken in order to ascertain what type of equipment was most suitably adapted for the burning of this local coal.

The company's plant in Meadville is equipped with pulverized coal burning equipment and the Lewistown plant at Lewistown, Pa., is equipped with two different types of stokers. These two plants therefore furnished the opportunity to conduct these experiments since the coal could be tried out with both classes of equipment. Accordingly about 32 carloads of this local coal was tried out at these two plants and the result was that this local coal could be burned most economically and

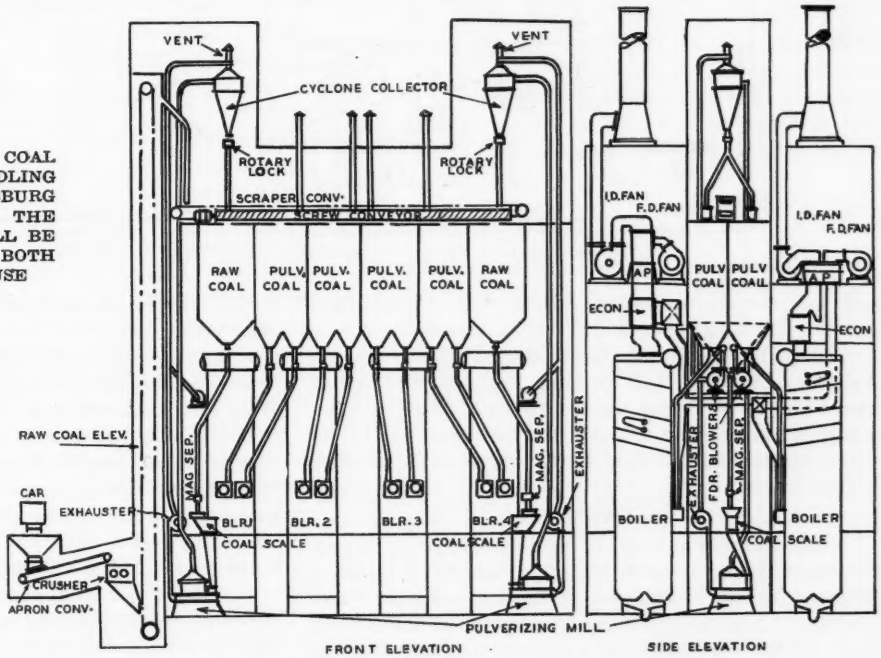


FIG. 1. DIAGRAM OF THE COAL HANDLING, AND AIR HANDLING SYSTEMS AT THE PARKERSBURG PLANT OF THE VISCOSE CO. THE RAW COAL BUNKERS, IT WILL BE NOTED, ARE PLACED AT BOTH ENDS OF THE BOILER HOUSE

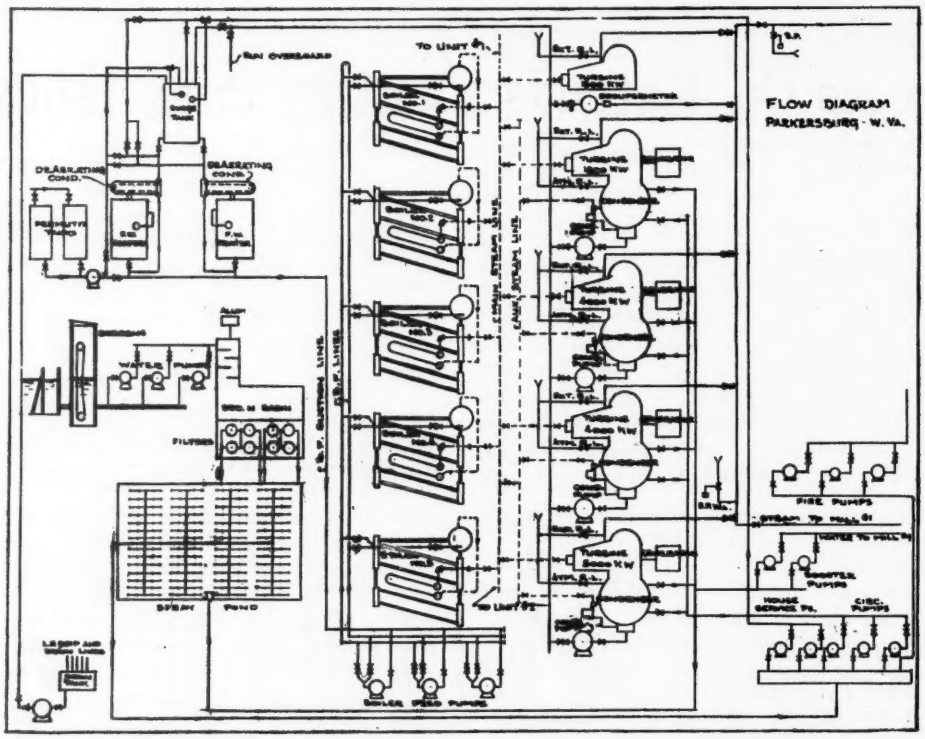


FIG. 2. SCHEMATIC PIPING DIAGRAM OF THE BOILER AND POWER HOUSE

with less trouble in the pulverized form. Pulverized coal burning equipment was therefore adopted.

This plant is expected to use from 110,000 to 120,000 tons of coal per year and by using local coal a saving of from $1.50 to $1.75 per ton is expected. Furthermore, it was found possible to cut down the total number of boilers necessary from eight to five, all units being rated at 1000 hp.

Boilers

A considerable number of layouts were made in connection with the present boilers in order to obtain a sufficient furnace volume and maximum available steam generation from each boiler. The height of the present boiler setting permitted the design of a furnace having a volume of 8100 cu. ft. to generate 120,000 lb. steam per hour. This being a determining factor for the number of boilers necessary, one additional boiler was added to generate 120,000 lb. steam per hour, with a similar furnace design having a volume of 8100 cu. ft.

The changes in furnace design to suit present stoker setting to pulverized coal equipment, required quite a change in the present boiler house, such as coal bunkers, coal handling system, lowering boiler room operating floor to accommodate burners, change of ash handling system and additional pent houses over the cyclone collector, etc.

A comparative estimate was made between leaving the present boilers as they are and installing new equipment, and making the changes mentioned above. The result showed that considerable savings would be realized by making modifications to the present boilers towards increasing their capacity from 75,000 lb. per hr. to 120,000 lb. per hr., as well as making it possible to use local coal.

The steam requirement of the entire plant is 480,000 lb. per hr., 95 per cent of which is furnished at 15 lb. pressure at the power house; 270,000 lb. of this steam is obtained from extraction type turbines in the power house and the balance goes through a pressure reducing valve and desuperheater. The pressure reducing valve is operated automatically so that, as soon as the pressure on the 15-lb. line drops below 15 lb., the reducing valve automatically opens and retains the 15 lb. pressure. When the steam demand is below the limit of extraction steam available in the power house, the turbines respond to the fluctuations.

In the boiler and power houses, there is steam at three different pressures: main steam at 250 lb. and 175 deg. superheat, mill steam at 15 lb. pressure and 20 deg. superheat and low-pressure steam at 5 lb. pressure which is used for raising the temperature of the feed water up to 220 deg. F.

The power house auxiliaries are chosen so that a certain number of steam-driven auxiliaries can be put into operation to keep the low-pressure line at 5 lb. pressure. In addition to this, there is an auxiliary line which gives from 15 lb. to 5 lb. steam through a pressure reducing valve. This valve is set so that if the low-pressure steam line goes below 5 lb., this valve will open and furnish sufficient quantity of steam to keep the pressure within ½ lb. All the low-pressure station drain and drip lines are collected to a low-pressure tank from which water is pumped into a surge tank.

Raw Coal Handling System

The raw coal handling system is shown on the diagram of the air and coal handling system in Fig. 1. A 14-ft. square track hopper is provided, equipped with a reciprocating feeder at the lower end. This feeder delivers coal to an apron conveyor which in turn sup-

plies a double roll crusher. From the crusher the coal passes by means of a vertical bucket elevator to a horizontal scraper conveyor and is thus delivered into the raw coal bins. There are two of these raw coal bins, one at each end of the boiler house as shown in Fig. 1, each bin has a capacity of 20 hr. storage under maximum steaming conditions.

Pulverized Coal Preparation

Raw coal from the bunkers is delivered by gravity through a magnetic separator and then into a weighing scale. The motor drives on the magnetic separator and coal scale are electrically interlocked so that at each automatic dumping of the coal scale the motor drive on the magnetic separator stops until the coal scale is back into its normal position. This arrangement is provided to prevent overloading the coal scale while it is weighing. Coal from the weighing scale is discharged into the pulverizer below through the pulverizer feeders.

The entire system is operated under a slight vacuum. This, of course, prevents dust from being scattered throughout the plant. From the pulverizers, the coal is blown into a cyclone collector at the top of the boiler house where the coal and air are separated and the coal then passes through a rotary valve into a screw conveyor which discharges it into any bunker desired. There are four pulverized coal bunkers. Pulverizing equipment includes 2 to 15-ton mills. In case one pulverizer is down for repairs, the other can be used and pulverized coal can be distributed by either screw conveyor or by changing the direction of rotation of the screw conveyors. Both raw and pulverized coal system motor drives are electrically interlocked so that in case any one of the motors in the circuit stops all motors preceding it are tripped off at once, preventing accumulation of coal that can not be handled.

Feedwater and Make-up

Because of the nature of the manufacturing processes, a considerable amount of steam leaving the power plant cannot be returned and a certain amount of make-up feedwater is required. This varies from winter to summer and usually ranges between 25 and 35 per cent of the total quantity of water in use. This feedwater make-up is treated by means of zeolite water softener system. This method has been used ever since the first water boilers were placed in operation and has found to be satisfactory. Two deaerating type feedwater heaters are provided, each capable of raising the temperature of 250,000 lb. of water per hour from 135 to 220 deg. F. Each one of the heaters is equipped with deaerating and heating trays so as to eliminate all the dissolved oxygen and CO_2 that may be in the water. All mill and power house condensate is delivered directly into a surge tank. One 4-in. Permutit water line is connected to this tank, which is float control so as to maintain the height of the water in the surge tank at a predetermined level. A second float valve is located 24 in. below the Permutit line to furnish untreated water in case of an emergency.

Ash Handling

The ash from each furnace will accumulate in an air-cooled furnace bottom, which is equipped with four ash gates. The nose castings, which support the refractory furnace lining around the periphery of each gate, are water-cooled. This prevents slag formation from freezing onto the gate.

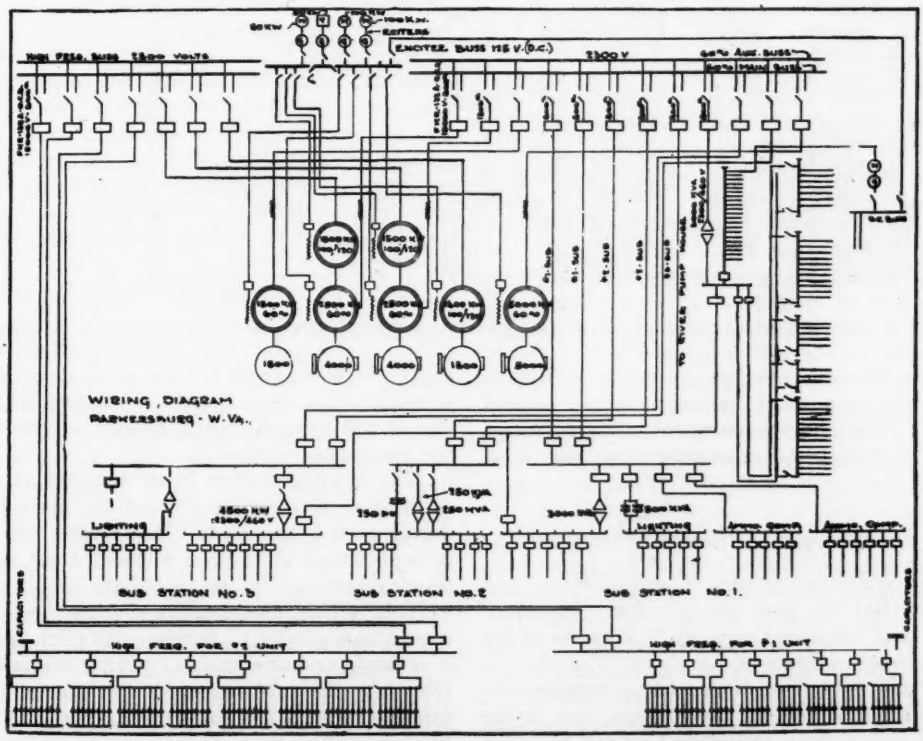


FIG. 3. SINGLE-LINE WIRING DIAGRAM OF THE STATION

Ash is removed by means of the hydrojet system. The clinker chambers of the system extend from the furnace bottom to the floor, above the discharge trench. Two clinker chambers are used, each serving two gates, and inside of each are located two feed plates, sloping toward the discharge trench. An oscillating feed nozzle is installed to direct a high pressure water stream up each feed plate; thus as the gates are opened, one by one, the backwash from the nozzle feeds the ash into the discharge trench. Here water from other nozzles carries the refuse through the trench, which is located beneath the floor, to a sump, equipped with a vertical pumping unit. This pump removes the ashes as fast as they enter the sump, and discharges the ash laden water to fill.

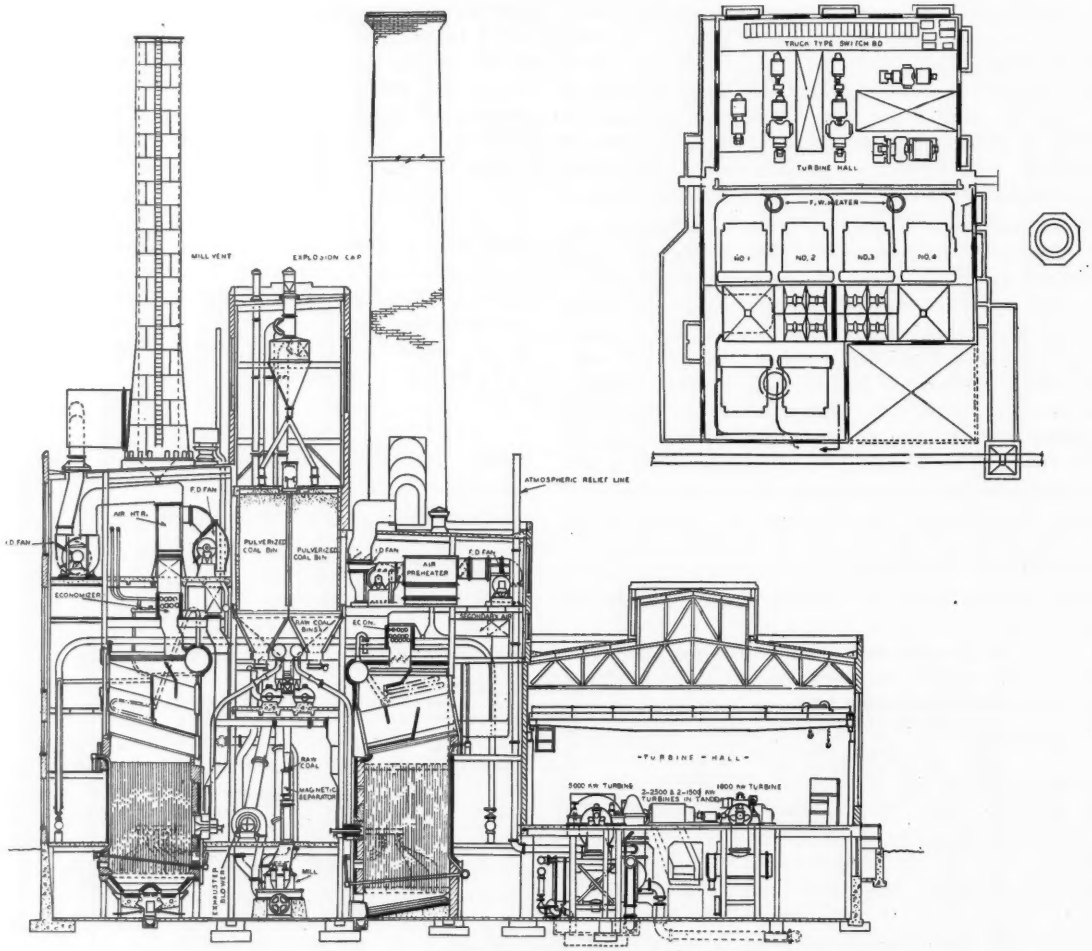


FIG. 4. SECTION AND PLAN OF THE PARKERSBURG PLANT OF THE VISCOSE CO.

Electrical Units

Generating equipment consist of one 5000-kw., two 4000-kw., one 1800-kw., and one 1500-kw. generators. Thirty per cent of the above capacity is in excess of the maximum load requirements of the plant. The plant is still large enough for one or more turbo-generator sets.

Each substation is fed by two feeders, one feeder being large enough to carry the entire load and the other one a duplicate for emergency. Under ordinary conditions of operation, both of these feeders from the power house to the substation are used to carry current.

About 60 per cent of the motors in the plant are of the induction type and for 440-v. operation; the larger synchronous motors are of 2300 v. These large motors will be used for power-factor correction.

The feeder for the auxiliaries in the power house is taken directly from the 2300-v. main bus through a transformer to the 440-v. distribution line.

The control panel is entirely push-button operated, and derives its supply from a small motor-generator set across which is floated a storage battery that for a short period will furnish control energy in case of failure of the motor-generator set.

The lighting system is on 60-cycle current and in addition to this each section of the plant has a steam-driven pilot lighting set. The throttle valve of this set is kept closed through a solenoid energized from the 60-cycle current. In case of failure, the 60-cycle current solenoid will be de-energized and the throttle valve will open automatically to generate the pilot lighting set, as it is shown on our single line wiring diagram. The high frequency lines are equipped with enough static capacitors to overcome the reactance drop of the transmission lines, as well as increasing the power factor of high frequency generators in the station.

Exhaust Turbo-Blower Supercharger for Diesels

ADVANTAGES GAINED BY USE OF TURBO-BLOWER FOR SUPERCHARGING DIESEL ENGINES. RESULTS OF TESTS SHOWING INCREASE OF POWER. BY F. JOHNSTONE TAYLOR

SOME ENGINEERS consider the double-acting Diesel engine, despite its proved success, to be limited principally to the marine field. A single-acting engine has a simpler construction but the smaller space requirement per horsepower of the double-acting type more than compensates for the greater complication in marine practice.

By improving the conditions of combustion and using materials which will stand the heat stresses set up, the power per cylinder in Diesel engines has gradully increased to a stage where normal methods of induction do not appear to admit of much further increase in cylinder size. But there appears to be a demand for larger sizes not only in the marine but also in the stationary field.

DESIRABILITY OF FORCED INDUCTION OF AIR

It has long been appreciated that some system of forced induction, by which the cylinder may be charged with more air than is represented by the volumetric displacement, would add to the power of the engine and many two-cycle engines of practically standard construction are arranged for this by a liberal output from scavenge pumps, while in the case of engines having turbo-blowers for this purpose, the superchanging effect can be controlled to an appreciable degree.

At the same time, there is a good deal more at issue than merely pumping extra air into the cylinders by this method and in any case it is inapplicable to four stroke engines which besides being well suited to supercharging, are by no means obselete. In the case of four-cycle engines there must be for this purpose either an independent air pump or the under side of the piston, assuming it to be a single-acting engine, must function as an air pump and while this latter system is being experimented with, considerable progress has now been made with separate blowers operated by an exhaust gas turbine.

GENERAL PRINCIPLES

This principle is now applied to airplane engines, where it is a relatively simple proposition and was used to some extent during the war. So far as Diesel engines are concerned, several interesting problems arise and the present system which is being developed by Brown Boveri in conjunction with the Swiss Locomotive Co. and the North Eastern Marine Engineering Co. and Messrs. Rateau in conjunction with Burmeister and Wain, owes its development largely to the Swiss designer, M. Buchi.

In this system the exhaust gases of the engine are led to a turbine which is direct coupled to a turbo blower, the pressure pipe of which is connected to the suction valves of the engine. The amount of air introduced into the cylinders is therefore considerably more than that which could be inducted by suction and as the fuel injection can be increased in the same ratio, the engine can produce proportionally more power. While this is all quite obvious, the important point in this particular system lies in the fact that the usual type of engine will stand up quite well to this overloading principally because the added blast of air assists in cooling the cylinder and for other reasons to be discussed presently.

ARRANGEMENT OF PLANT

Supercharging by means of the blower shown in section in Fig. 1 and which is designed on the Buchi system and built by Brown Boveri for a six-cylinder 1880-hp. Diesel engine, operating at 138 r.p.m. increased the output of that engine 52 per cent, the indicated m.e.p. and brake m.e.p. being increased from 98 and 75.5 to 134 and 110 lb. per sq. in. respectively.

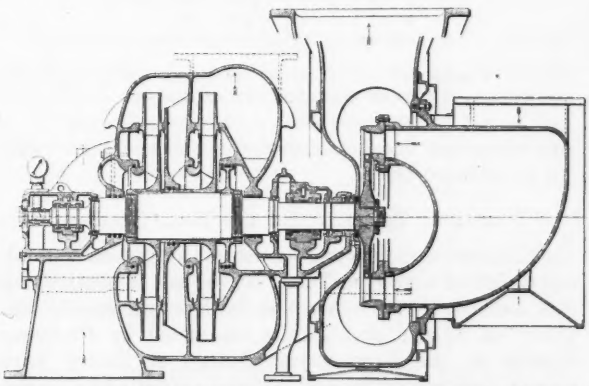


FIG. 1. CROSS SECTION OF TURBINE-DRIVEN BLOWER FOR SUPERCHARGING DIESEL ENGINES

It will be seen that the blower comprises two wheels and one single-stage turbine mounted on a common shaft, the impellers being supported in two bearings while the turbine wheel is overhung. The thrust is small and is taken up mainly by a balancer piston, although one of the bearings functions also as a thrust bearing. The turbine wheel is constructed of special heat-resisting steel and the casing is divided horizontally, while the turbine casing is bolted to the forward end of the blower casing, on the forward end of which is a casting carrying the nozzle plates and exhaust gas distributing passages.

Forced lubrication is taken from the engine system. This particular blower, which is typical of both larger and smaller sizes, except that in the latter case one impeller is used, has a delivery capacity of 8000 cu. ft. per min. at 4.7 lb. and 5000 r.p.m. with an exhaust gas pressure of about 4½ lb. at a temperature of 930 deg. F.

It has been proposed in some quarters that better results could be obtained by having one turbine and blower attached to each cylinder but that appears to be a needlessly complicated arrangement. In the present instance, the exhaust pipes discharge through distributing passages above a separate set of nozzles from which they impinge on the vanes of the turbine wheel and the

streams do not mix until they have passed the wheel. This actually has an important bearing on the particular system outlined because it is essential that the exhaust system be so laid out that interference between the exhausts of different cylinders is avoided so as to permit of efficient scavenging, which as previously mentioned is an important element in the working principle.

The exhaust gases leave the turbine by a common pipe and after passing through an expansion chamber, they are discharged to atmosphere. The air is drawn into the blower through a pipe connected to the top half of the casing, passing thence to an air main running along the outboard side of the cylinder heads. Bypasses

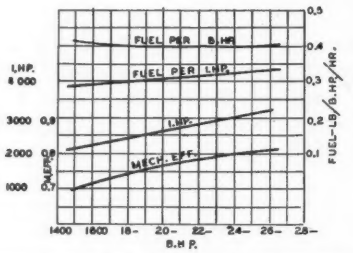


FIG. 2. TESTS BY PROFESSOR HAWKES SHOW ADVANTAGE OF USING SUPERCHARGER

and valves are fitted so that the engine can work without supercharging.

Pressure, Temperature and Heat Stresses

Fifty per cent increase of normal output of a standard design of four-cycle Diesel engine can be obtained by this method of supercharging, with a mechanical efficiency of 82 per cent. Tests conducted by Professor Stodola at the Engineering College at Zurich have proved conclusively that the normal output of an engine so fitted can be increased at least 50 per cent and up to 100 per cent, for short periods, while the temperatures of combustion and of the exhaust gases are the same or even lower than when the supercharger is out of action. The fuel consumption per brake horsepower is lower and less heat is carried away in the cooling water, the absolute amount of the latter being about 43,000 B.t.u. per hr. per sq. ft. of piston area, which is quite a low value.

Cooling Effect on Cylinder Walls

An engine fitted with an exhaust turbo-charger, which must not be confused with an ordinary supercharger, shows a relatively low mean temperature at the end of the exhaust stroke and at the commencement of the suction stroke. There is an effective-cooling of the cylinder walls and as the compression ratio is relatively small, the rise in temperature is correspondingly less. If, during combustion, the amount of fuel introduced is also in the same proportion to the volume of air in the cylinder of both types, it will be obvious that the rise in temperature during combustion will be the same.

It follows, therefore, that for the same amount of excess air, the maximum combustion temperature of the supercharged engine is the lower of the two. During expansion the temperatures in both types are similar because the combustion in the turbo-charged engine lasts longer and the temperatures are also the same at the commencement of the exhaust stroke. At the start of the scavenging period, however, the temperature of the turbo-charged engine drops below the values found in ordinary four-cycle Diesel engines. The result is that the mean temperatures of the whole working cycle are lower.

It might be argued, in the case of a supercharged engine, that on account of the increased quantity of fuel injected the heat stresses in the walls, piston heads and cylinder heads must increase considerably. But actual tests, as already pointed out, have proved conclusively that in the turbo-charged engine the transfer of heat through the cylinder walls is less than it is in the case of an ordinary engine, as indicated by heat measurements of the jacket water.

Tests

Comprehensive data on this particular point are provided by the tests made by Professor Stodola in Zurich. These deal, in the main, with determining the conditions present in turbo-charged engines and they are well worth study by the engine designer. Tests by Professor Hawkes at the works of the North Eastern Marine Engineering Co. provide a lot of interesting data concerning the test trials of a 24.4 by 51.2-in., six-cylinder marine engine developing 2750 hp. at 138 r.p.m. and they indicate the success of the system.

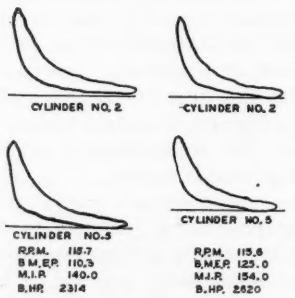


FIG. 3. INDICATOR CARDS TAKEN FROM ENGINE OPERATING WITH SUPERCHARGER SHOW EXCELLENT CYLINDER CONDITIONS

From a large number of graphs, diagrams and tables issued with the report one, Fig. 2, is of particular interest. It shows a practically constant fuel consumption of 0.4 per br. hp-hr. while the typical indicator diagrams, Fig. 3, show the excellent conditions existing in the cylinders.

Principal values tabulated from the test results include the following which give a good indication of the performance: Fuel per br. hp. = 0.4 lb.; brake m.e.p. at 1485 hp. = 69.9 and at 2620 hp. = 115.6 lb. per sq. in.; brake m.e.p. on which the engine is rated = 110 lb. per sq. in.; average speed = 116 r.p.m.; mechanical efficiency at maximum horsepower = 81.1 per cent and the average thermal efficiency = 32.4 per cent; indicated m.e.p. at 1485 hp. = 101 lb. and at 2620 hp. = 154 lb. per sq. in.; corresponding compression pressures = 496 and 595 and the discharge pressure of the blower at 1485 hp. = 16.21 lb. abs. while that at 2620 hp. = 19.4 lb. abs.

Rateau Application of Supercharging

Further tests at the instance of Messrs. Rateau deal particularly with the working of the superchargers and the layout of the test plant as shown in Fig. 4 is of

interest. Here the air discharged from the blowers is taken through a pipe C to a specially devised combustion chamber G, at which is a stop valve F. Normally, of course, the air would be led to the inlet pipe of the engine.

In the combustion chamber the temperature of the air is raised to about 840 deg. F. corresponding to the exhaust gas of the engine, the necessary heat being obtained by fitting an oil fuel burning system with a burner at L. An electrically-driven pump P supplies the fuel through a heater O. A pressure gage M and a pyrometer T are provided for ascertaining the pressure and temperature of the combustion chamber while pyrometers T_1 and T_2 are fitted on both sides of the turbine. The hot gas passes from the combustion chamber through a pipe H and exhausts to atmosphere through a pipe N. The combustion chamber is also provided with a peep hole, observations being made through

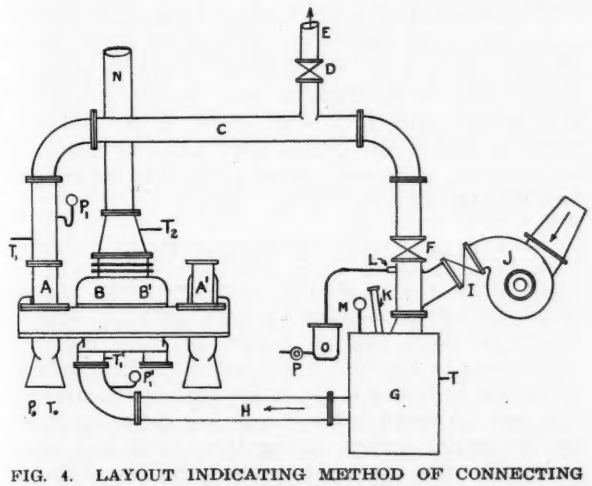


FIG. 4. LAYOUT INDICATING METHOD OF CONNECTING SUPERCHARGER TO ENGINE

the inspection tube K. An auxiliary starting blower is provided in order to commence the required operations. This blower J discharges into the circuit above the combustion chamber, a valve I being installed in order to isolate the blower when the apparatus is working normally.

It should be observed also that when starting, the discharge of the main blowers is carried to the atmosphere past a valve D and through an exhaust pipe E with the isolating valve F shut. Accordingly, when combustion has started in the chamber and the turboblower has reached the number of rotations required for the test, the valve F is opened and those at I and D are closed, while at the same time the auxiliary blower J is stopped.

Overall efficiency of the turbine may be considered in two ways: The engine may be supercharged with an admission pressure to the turbine appreciably below that of the discharge from the blower while the exhaust gas temperature is in the neighborhood of 840 deg. F. or, alternatively, the supercharging may take place with a pressure corresponding to that of the exhaust gas entering the turbine, when an exhaust gas temperature of rather more than 572 deg. F. would satisfy the conditions.

RESULTS OF TESTS AT DIFFERENT TEMPERATURES

Speed r.p.m.	6110	4200	5770
P_1 Pressure of discharge of blower, mm. of mercury	255	112	214
P_1' Pressure of admission to turbine, mm. of mercury	212	93	160
P_o' Pressure of exhaust of turbine, mm. of water	80	34	60
T_o Temperature of inlet to blower, deg. C	28	29	29
T_1' Temperature of entry to turbine, deg. C	362	384	451
T_2 Temperature of turbine exhaust, deg. C	335	365	...
T_1 Temperature of discharge of blower, deg. C	47.7	37	47.3
Total efficiency E per cent	61.0	58.4	57.3

In calculating the total efficiency, referring to the table,

$$E = (P_1 - T_1) \div (P_1' - T_1')$$

An efficiency for an exhaust gas temperature of 684 deg. F. corresponding to the data in the first column is therefore 61 per cent. It is also of interest to consider the scavenging effect which takes place at the top of the exhaust stroke and which has previously been stressed. This effect is equivalent to

$$P^1 - P_1^1$$

If one selects figures from the first column again, the result is 255 — 212 mm. of mercury equal to 43 mm. or 17 in. of mercury which corresponds to 0.8 lb. per sq. in.

AFTER MAINTAINING the lead for several years in the production of natural gas, Oklahoma dropped into second place in 1929, according to a report of the United States Bureau of Mines, Department of Commerce, Washington, D. C. Texas, by virtue of a 54 per cent gain in output, became, for the first time, the leading natural gas producing state. This resulted primarily from a material increase in production in the panhandle area. The report shows that Oklahoma produced 357,893,000,000 cu. ft. of natural gas last year while Texas produced 464,928,000,000 cu. ft. The Oklahoma figures showed a gain of approximately 11 per cent over production of 1928. California stood third with 342,214,000,000 cu. ft.; Louisiana, fourth, with 261,138,000,000 cu. ft. and West Virginia, fifth, with 167,333,000,000 cu. ft. There were at the end of last year 225,000 natural gas consumers in Oklahoma, according to the report. Oklahoma, last year, consumed 247,539,000,000 cu. ft. of natural gas for field drilling, pumping, operating gasoline plants, etc., leading all other states. The nearest competitor in this class was California, which consumed 216,337,000,000 cu. ft. Domestic consumers of Oklahoma used 31,263,000,000 cu. ft. of natural gas and the remainder was used for various industrial purposes. Figures for the nation showed a total gas production last year of 1,917,693,000,000 cu. ft., an increase of about 22 per cent over 1928.

OIL CHANGES in both specific gravity and viscosity with change in temperature.

Electricity---What It Is and How It Acts*

PART XLVI. CRYSTAL STRUCTURE. ITS SIGNIFICANCE AND ITS RELATION TO X-RAYS. LANE'S DISCOVERY. BY A. W. KRAMER

IN OUR CONSIDERATIONS of the various theories of magnetism, it was shown that the magnetic properties of a material were due not only to the disposition and the rotational characteristics of the electrons within the atoms, but also to the configuration in the substance of the atoms themselves, that is, upon the crystal structure of the material. This is not surprising. Crystal structure is of fundamental importance, not only in determining the magnetic qualities of a substance, but also in determining the majority of other physical characteristics.

Since this question of crystal structure is of such fundamental importance, it will be of interest to show

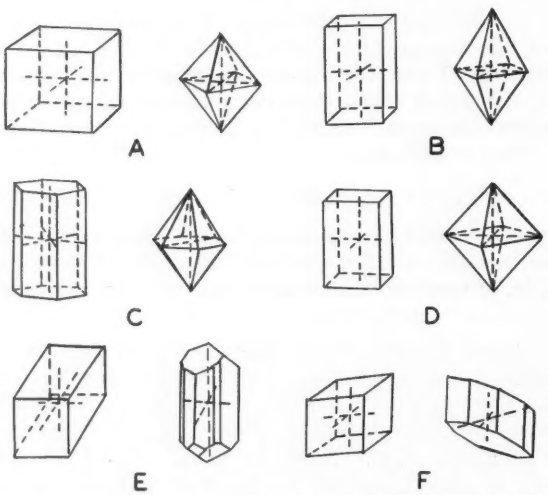


FIG. 1. THE VARIOUS SYSTEMS OF CRYSTAL CLASSIFICATION

A. Regular (Isometric). B. Square prismatic (Tetragonal). C. Hexagonal. D. Rhombic (Orthorhombic). E. Monosymmetric (Monoclinic). F. Asymmetric (Triclinic).

how the whole subject of crystal structure is related to electron and associated phenomena.

To begin with, what is meant by crystal structure? What is a crystal? All substances may be divided into two classes—amorphous and crystalline. Under the former, we have liquids and glassy solids in which the arrangement of particles is chaotic—not according to a definite pattern. A crystalline substance, on the other hand, is one in which the particles are arranged in definite order, like trees in a nursery or soldiers on parade.

This idea of a regular, underlying structure has always been at the back of scientific studies of crystals. It is suggested by their very appearance and their behavior under stress. Crystals possess marked properties of cleavage—they split only in certain directions and in such a direction such splitting may be carried out, as in the case of mica, into sheets of inconceivable thinness. It has been estimated that a single sheet may be only *two* molecules thick.

It was the regular structure of crystals that led Christian Huyghen, in the 17th century, first to put forward the idea that a crystal was essentially a regular piling up of atoms or molecules, similar on a minute scale to the piling up of shot. Later, at the beginning of the 19th century, this idea was placed upon a firm mathematical footing by Abbé Haüy. Abbé Haüy's idea was that crystals consist of a regular ordering of exactly similar molecules in three dimensions.

It is evident that if this is true, the smallest possible crystal will have exactly the same shape as the large one, and this is true. Crystals are formed by growth; a small group of molecules or atoms arrange themselves in a certain pattern (due of course to the electrical forces between them) and as more atoms or molecules are attracted, the crystal grows in size but the general form remains the same.

CLASSIFICATION OF CRYSTAL FORMS

As crystals were studied more and more, it was found that notwithstanding the large number of crystalline forms which exist in nature, all crystalline substances may be classified in six systems. These systems are defined according to the nature of their fundamental axes, and are shown in Fig. 1. At A is shown the Regular (Isometric) system, having three equal and interchangeable axes at right angles. Sodium Chloride (Na Cl) lead sulphide (Pb S) and in fact, most metals belong to this system. At B is the Square Prismatic (Tetragonal) system with three axes, all at right angles, two of which (the lateral) are interchangeable. Zircon ($Zr\ Si\ O_4$) and Nickel sulphate ($Ni\ SO_{4.6}\ H_2O$) are members of this group. The Hexagonal system shown at C has four axes, three of which are interchangeable, being in the same plane and at an angle of 60 deg. to each other. All are at 90 deg. to the fourth axis. Quartz ($Si\ O_2$) belongs to this system. The Rhombic (Orthorhombic) system with three unequal axes, all at right angles is shown at D. Another system E the Monosymmetric (Monoclinic) system has three axes all unequal, two of which are at right angles. One of these is at right angles to the third or C axis; the other is inclined. The sixth system F is called the Asymetric (Triclinic) system. This has three axes, all unequal and inclined. A seventh system, the trigonal or rhombohedral system is not shown in the diagram, but its axes are the same as in the hexagonal system. The crystal develops according to two patterns, one repeated three times at intervals lying 120 deg. apart in a plane and the other twice in the direction at right angles to that plane.

This method of classifying and arranging crystals was worked out years before any knowledge of the internal structure of crystals became available and is part

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of the general study of crystallography. These arrangements need concern us here only incidentally, for it is our purpose to discuss the development of the science of crystal structure as influenced by the X-ray.

X-rays and Crystal Structure

From the year 1895 when Rontgen discovered the X-rays until 1912 when von Laue showed that they could be diffracted by crystalline structures, their relation to other forms of radiation was a matter of keen investigation and animated discussion. An extended controversy as to their nature arose, some maintaining that X-rays were corpuscles and others that they were waves similar to light waves.

In many ways X-rays resembled light. They moved in straight lines, cast sharp shadows, affected the photographic plate, excited substances to phosphorescence—all properties of light, yet in other respects they seemed to differ markedly from light. The mirror, prism and lens which reflected and diffracted light had no such effect on X-rays. Neither were they diffracted by gratings[1] nor were they polarized by crystals.

If it had been possible at the time to prove that the absolute velocity of X-rays in space was the same as the velocity of light, much would have been accomplished, but practically all efforts in that direction were unsuccessful.

Perhaps the strongest evidence against the similarity of the nature of light and X-rays arose from a consideration of the transference of energy by means of the X-ray. As was shown in an earlier chapter,[1] when a beam of cathode rays (electrons moving at light velocity) impinges upon the "target" in an X-ray tube, X-rays are produced. These X-rays in turn, impinging upon matter could be made to produce cathode rays. This in itself was remarkable enough but what was still more remarkable was that the speed of these "secondary" cathode rays which the X-rays produced was virtually the same as that of the cathode ray producing the X-rays. This was true regardless of the intensity of the X-rays or of how far from the tube, the production of secondary rays took place, or what the nature of the matter was from which the secondary electrons seemed to spring.

Today, this action is not so mystifying as it was when it was first discovered, for now we can explain it on the basis of the quantum theory, i.e., the energy can only be transmitted in definite quanta, but in the early days such an idea was distinctly foreign to the orthodox conceptions of the transference of radiation energy.

Yet despite these apparent inconsistencies in the behavior of X-rays, it had become increasingly evident that the phenomenon which appeared so irreconcilable with the light theory must in some way be made to fit in. The photo electric effect[2] of light had been investigated and was found to be of exactly the same nature as the X-ray action just described.

Laue's Hypothesis

Now early in 1912 it occurred to von Laue, then a young physicist at Munich who was in touch with the crystallographic school of Groth, that, if the theory that crystals consist of orderly arrangements of atoms was correct, a crystal should be able to diffract X-rays in exactly the same way that visible light is diffracted by the parallel lines ruled on a diffraction grating. If X-ray waves were as short as they were thought to be, Laue reasoned, the spacing between the lines of atoms in a crystal should be of an order sufficient to diffract these waves.

Von Laue's hypothesis aroused immediate interest and within a few months of its announcement two other German scientists, Knipping and Friederich, carried out the experiment of passing a narrow beam of X-rays through a crystal with a photographic plate behind it. The experiment was strikingly successful. The plate was covered with a regular pattern of spots, which was what von Laue had predicted. This experiment gave the key both to the nature of X-rays, and the structure of crystals.

Naturally enough, this new discovery aroused great interest and various investigators undertook the study of the actual grouping of the atoms in crystals. In England it was taken up by Sir William Bragg and

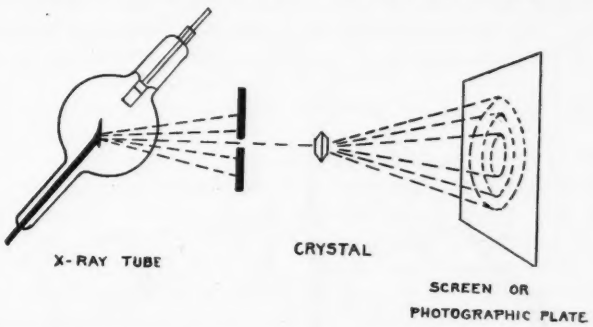

FIG. 2. THE LAUE METHOD OF X-RAY CRYSTAL ANALYSIS

his son, W. L. Bragg, who in the same year determined the first crystal structures, those of rock salt and zinc blende. The way in which they accomplished this, how they determined the wave length of X-rays and the structure of crystals is told in their classic book "X-rays and Crystal Structure." In these articles, it is impossible to give more than a brief sketch of the methods used—our object being merely to acquaint the reader with the general principles involved.

The important significance of Von Laue's discovery was in that it provided us with a microscope of such inconceivable power that it enabled us to look right into the spaces between the atoms of matter. It enabled us to measure the spaces, to determine their boundaries with a high degree of accuracy, and finally, it provided us with a measure by which to gage the wave length of the hitherto unmeasurable X-rays.

Laue's proposal was based on a brilliant extrapolation. A large proportion of our knowledge of light and optics was derived from investigations suggested by the wave theory of light. One of the most useful instruments used in the investigation of light was the spectrometer, particularly that form of spectrometer which utilized the diffraction grating. As explained briefly in chapter XXVIII, when visible light is reflected from a polished surface on which are engraved a large number of closely spaced (20,000 to 40,000 per in.) grooves. the incident beam will be broken up into its component colors or wave lengths. Now, the angle of diffraction so obtained is a function of both the wave length of

[1]See Part XXVIII, September 15, 1929.
[2]Part XXIX, October 1, 1929.

the incident light and the distance between the lines. If we know one, it is possible to calculate the other.

In order that such diffraction grating may be used it is necessary that the spacing between the lines be of the same order as the length of the wave to be measured. This was the reason that X-rays, with wave lengths some ten thousand times shorter than visible light could not be measured with the ordinary gratings used for light, for the spacing of the lines on these gratings, despite their smallness was much too coarse. And it was, of course, unthinkable to construct gratings for use with X-rays since the spacing necessary was of the same order as the distances between molecules.

Von Laue, therefore, conceived the idea of using the ordered arrangement of atoms or molecules in a crystal as a proper grating for diffracting X-rays. The spacing was of the right magnitude, and although the atoms were disposed in a space of three dimensions, the action of a crystal on a beam of X-rays, should be similar to the action of an ordinary diffraction grating on light rays.

And his conclusions were justified. When a beam of X-rays was passed through a crystal, it was broken

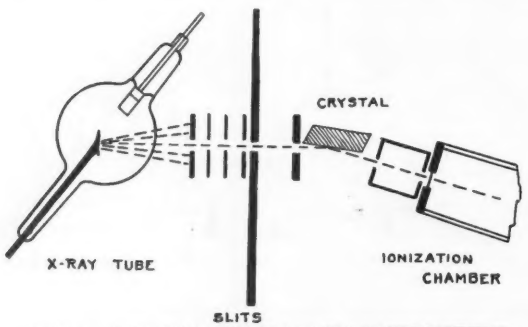

FIG. 3. THE BRAG IONIZATION SPECTROMETER

up into a group of rays each one of which left a dark spot on a photographic plate and each one of which represented the reflection of the X-rays by a plane of the crystal lattice. The reconstruction of the actual atom arrangement in the crystal from the pattern of spots on the photographic plate was a difficult mathematical task, but one which von Laue successfully mastered. The Laue method for determining crystal structure is shown in Fig. 2.

Another method for studying crystal structure was later developed by Bragg, in which the X-ray is reflected from the face of the crystal under investigation. For this purpose, an arrangement such as shown in Fig. 3 is used and is known as the Bragg ionization spectrometer. The X-rays from the tube inside the lead box pass through the two slits which limit them to a narrow beam, and meet the crystal mounted so that it can be rotated. The reflected beam is received in an ionization chamber in which there is an absorbing gas such as methylene iodide, producing ions which charge an electroscope. The angular position of the crystal gives the glancing angle and the ionization current is a measure of the intensity. In this way, a crystal can be explored, face by face, and a complete analysis made of its internal atomic structure.

Several other methods have been developed, which will be described after we have more thoroughly considered the principles involved in X-ray diffraction.

Danger from Low Voltage Circuits

CONTACT WITH THE SO-CALLED "low voltage" electric current, carrying charges of from 110 to 750 v., is always dangerous and under certain conditions, fatal. There have been more than 100 such cases which have resulted fatally in the United States and Canada during the past two years.

For the past year, a special committee of the American Society of Safety Engineers—Engineering Section, National Safety Council, has been studying low voltage hazards and the peculiar circumstances surrounding the cases which have come to its attention. The progress report which has just recently been completed reveals some interesting facts:

Forty-four, or more than two-fifths of 107 cases studied, were caused by the ordinary 110 alternating-current voltage. There were 58 purely industrial fatalities in the group, nine mine fatalities and four railroad tragedies. Home fatalities rank second to industry with 31 deaths. Bathtub fatalities led the domestic list with 12 deaths. Next in importance came fatalities from contact while on wet basements or earth, with seven fatalities. Portable appliances came next in the home with six tragedies, and amateur experiments caused one fatality. There were several instances where the victims were working under cellarless houses with portable electric lamps.

Most of the bathtub cases involved the use of electric heaters, on which the insulation of the connecting cord was defective or was handled with wet hands. In one case, the curling iron provided the contact with the circuit. The domestic cases also included two fatalities from electricity occurring while the victim was in bed. In one of these an electric heater set fire to the bed clothes and in the other a man was found dead wearing an electric blanket, the death evidently occurring while he was wet with perspiration. All of the domestic fatalities occurred at approximately 110 v.

In securing data for the committee, the National Safety Council and the National Electric Light Association each conducted separate inquiries into the cases available. The latter organization found that 45 of the 106 cases studied involved the use of defective materials. Thirteen of the deaths were due to handling exposed wires; 11 fatalities resulted from working or handling live parts and there were six flagrant violations of the National Electric Code.

The report shows that at least one-third of the fatalities may be attributed to defective materials such as the lamp cord not properly maintained; 5 to 12 per cent are due to installations not in accordance with standard practices as represented by the National Electric Code; 10 to 15 per cent are due to handling live parts and about 8 per cent more to improper practices from which are excluded the ignorant handling of radio aerials and a few disastrous amateur experiments.

A CONVENIENT and serviceable syphon for a steam gage can be made from four street ells screwed into each other so as to form a rectangular fitting.

THE TRUE TEST of any coal is in the burning of it.

Protection *and* Metering *for* Three-Wire Circuits

By JOHN AUCHINCLOSS
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IN THE CIRCUIT previously[1] described, it was stated that the sum of the three-line currents is always zero; however, in the case of a four-wire circuit this is not necessarily so, nor even likely to be so, since one of the primary objects of the four-wire system is to provide single-phase lighting voltage from any phase to the fourth or neutral wire, while at the same time permitting polyphase motors to be operated from the three-line voltages. In the event of a single-phase fault developing from one line to neutral, the excess current will not flow over either of the remaining lines but must flow in the neutral wire.

Consider an overcurrent condition occurring between line 2 and neutral on a four-wire circuit equipped with but two protective devices, as shown in Fig. 25. Obviously the excess current flows only in line 2 and the neutral wire; neither protective device is actuated by it and the breaker consequently fails to open and relieve the trouble. On the other hand, were the breaker equipped with three protective devices as shown in Fig. 26, the overcurrent coil connected in line 2 should respond to the excess current and open the breaker. Comparing Figures 19 and 26 it is apparent that approximately the same degree of protection is provided in both cases, inasmuch as the failure of one protective device might prove disastrous. A line to neutral fault, however, with the failure of the proper protective device would probably soon develop into a short across phases (the neutral being usually grounded) thereby bringing into action one or both of the remaining protective devices.

[1] November 15 issue, page 1282.

To obviate the possibility of a phase-to-neutral fault developing into a phase-to-phase short, a very sensitive protective device connected in the circuit neutral and operating on the so-called "residual" current, or current of zero phase-sequence, is often employed on more important distribution lines, especially where the maximum fault current developed on a line-to-neutral fault may not be of sufficient magnitude to operate the protective device of higher current setting in the main phases.

This residual current corresponds in value to the current passing to ground. Since the secondaries of the current transformers in the unaffected phases offer an extremely high impedance to the flow of the ground current in the faulty phase, this current passes over the low impedance of the fourth or secondary neutral wire. The ground relay (Fig. 27) is consequently inserted in this wire, which gives it a torque proportional to the amount of ground current flowing in the affected phase. Its sensitivity enables it to operate and so isolate the line on very low values of ground current.

By the use of current with current, or current with potential, these relays may be made discriminatory or directional in their action. Their principal application in this form of construction lies in the field of interconnected systems where normal neutral grounds are maintained at various points. Their function on the occurrence of a ground is to prevent the opening of unnecessary breakers and thereby confine the resulting interruption to the affected area only. The non-directional and directional forms are illustrated diagrammatically in Figs. 27 and 28 respectively. In the latter figure,

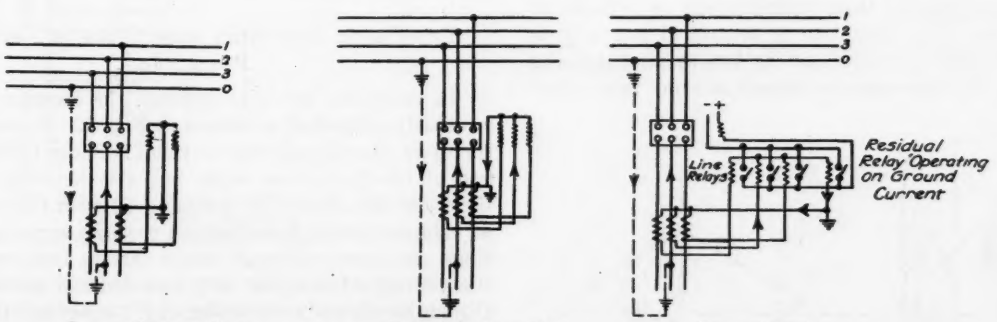


Fig. 25 Ground fault on three phase 4-wire circuit with 2 over-current units.

Fig. 26 Ground fault on three-phase 4-wire circuit with 3 over-current units.

Fig. 27 Ground fault with residual relay

FIGS. 25-27. FAULTS WITH DIFFERENT SYSTEMS OF PROTECTION

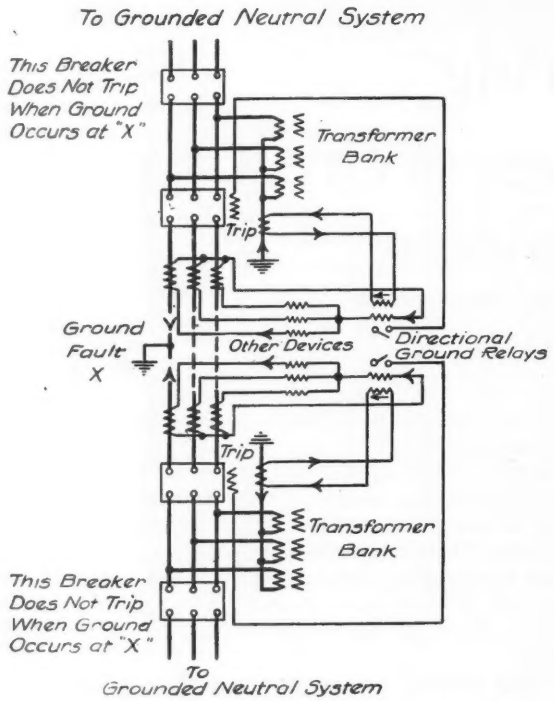


FIG. 28. SHOWING ISOLATION OF GROUNDED LINE BY MEANS OF DIRECTIONAL GROUND RELAYS

it will be noted that the respective polarity of the two windings of the relay determines its direction of torque, either to close the contacts or to hold them open. This polarity in turn is dependent upon the direction, with respect to the relay, in which the disturbance has occurred, as will be apparent from the instantaneous direction of the ground current arrows shown in the figure. This method is particularly applicable to systems of low resistance normal grounds. Where this resistance is purposely high, a potential transformer may be connected across it and a voltage coil substituted in the relay. On the occurrence of a line ground, the drop across the ground resistor then energizes the relay coil so that the net result is similar to that already described under the straight current-current relay.

Since a ground occurring at some other point on the system beyond the particular line shown in Fig. 28 would obviously create a tendency for one or the other of the two relays shown to close its contacts, it becomes necessary to provide them with current or voltage settings so that their operation is controlled not only by the direction of the fault current but by its value also. With this arrangement, a distant ground fault is relieved by the relays nearest to it, which of course receive the greater part of the fault current. The action of the relays may be still more accurately controlled by the use of time settings.

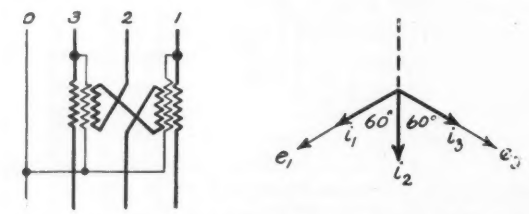


FIG. 29. 2½-ELEMENT METER ON THREE-PHASE, FOUR-WIRE CIRCUIT

METERING

Where the neutral of the system is brought out and current carried over it, as is usually the case on a three-phase four-wire system, it is obviously impossible to measure the total power directly by means of the conventional two-element meter and two current transformers, since this meter takes cognizance of the current flowing in two phases only and is unaffected by any single-phase current flowing over the third phase to neutral. If current transformers in the three main lines, however, are available, as is necessary for protective purposes, it is possible to connect the secondaries in delta, using voltages to neutral, so that the current in all three phases may be registered on a two-element meter. Where current transformers are not used, however, as on primary current meters, this method cannot be applied. In such cases, a meter equipped with three current and two potential coils (voltage to neutral) has been frequently used. If we consider the disc as the element, this device is essentially a two-element meter, although to distinguish it from the commoner two-element meter it has been usually referred to as a two-and-one-half-element meter, the term being derived from the fact that the middle current coil is split in halves, each one of which exerts a torque upon the discs with the voltage to neutral of an adjacent phase. This meter is shown diagrammatically in Fig. 29.

The formulas for the torques developed in the two-element meter with delta-connected current transformers and the 2½ element meter with Y-connected current transformers, are very readily derived and will not be repeated here.* Since the voltages to neutral are employed with these meters the torque is of the form $3ei \cos \alpha$.

In the foregoing discussion on three-phase four-wire power measurement, it should not be forgotten that on the more important circuits where large blocks of energy are measured for billing purposes, and extreme accuracy is the prime desideratum, the complete three element meter (three current and three potential coils) is, of course, the ideal device. It should also be noted, however, that where instrument transformers are necessary this meter requires the use of *three* potential transformers instead of the two required by the two-and-one-half-element meter.

TWO-PHASE, FIVE-WIRE WITH COMMON NEUTRAL PROTECTION

In two-phase five-wire systems, the common neutral is usually grounded, as shown in Fig. 30. It is obvious, therefore, that a fault may develop not only between any two of the four-phase wires but also between each of them and the neutral, or ground. To meet this situation on minor circuits, four fuses in the line wires are sometimes employed, although under certain load conditions the blowing of one fuse may overload the neutral wire. On major circuits controlled by four-pole oil circuit

*For a description of the principle of operation of these meters, see "Various Methods of Connecting the Indicating Wattmeter" by John Auchincloss, General Electric Review, May, 1928, pages 262 and 263.

breakers, however, this is impossible. When relays are used with the breakers, they may be connected as shown in Fig. 31. From this diagram, it will be observed that no matter from what cause a fault develops, there is always a relay and trip coil to meet it. The relay contacts normally short-circuit the path to the trip coils, but the opening of the contact automatically places either trip

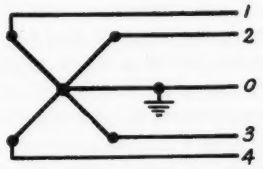
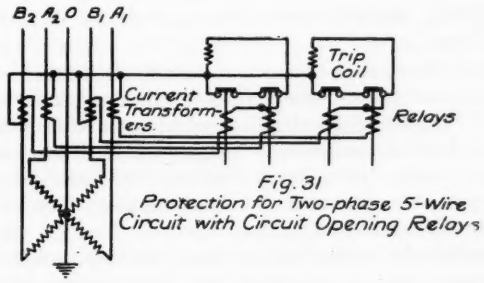
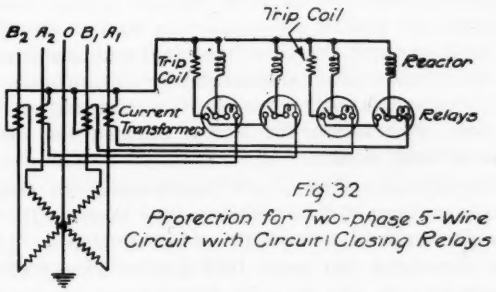


FIG. 30. TWO-PHASE, FIVE-WIRE SYSTEM





FIGS. 31-32. PROTECTION FOR TWO-PHASE, FIVE-WIRE CIRCUITS

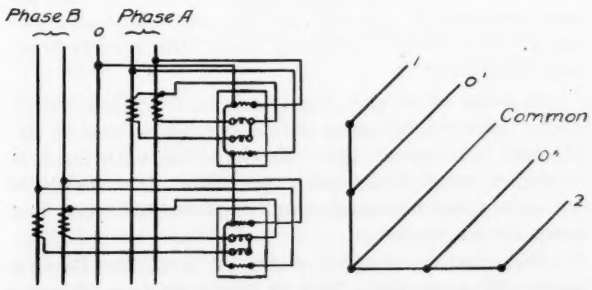


FIG. 33. TWO TWO-ELEMENT METERS ON TWO-PHASE, FIVE-WIRE CIRCUITS

FIG. 34. VARIATION OF CIRCUIT SHOWN IN FIG. 30

coil in series with the current transformer or transformers in the line or lines affected by the disturbance.

Figure 31 shows typical connections for this method of protection using relays equipped with circuit opening contacts which trip the breaker by means of the line current. Where circuit closing relays are required equivalent connections shown in Fig. 32 may be employed using reactors to obtain the necessary voltage across the tripping coils.

Overcurrent air circuit breakers on less important feeder circuits, particularly in office buildings, are also frequently used. These may be either of the four-pole type with an overcurrent device in each pole, or an equivalent combination of two double-pole, two-coil breakers equipped with a common tripping bar which automatically opens all four poles.

Metering

This may be accomplished in a variety of ways but for accurate measurement, regardless of load and voltage balance, four single-phase meters or their equivalent are required.

Possibly the simplest arrangement is to meter the complete circuit by means of two two-element meters as shown in Fig. 33. By this method, each meter records half the total power, each half of the complete circuit being treated as a straight single-phase, three-wire system, the neutral taking the place of the common wire for both. Obviously the same result could be obtained by means of a single four-element meter but as the two-element meter is standard, therefore readily obtainable, while the four-element meter is special, the latter is not usually recommended.

Another form of so-called two-phase, five-wire circuit is shown in Fig. 34. This is in reality a two-phase, three-wire system provided with two neutral points. Since it is not in very general use, the various problems connected with it will not be touched upon here.

Before concluding this article, it might not be out of place to refer to a meter problem which sometimes occurs during the transition period when an existing two-phase, four-wire system is being gradually changed over to a three-phase three-wire system. For a considerable time, some customers on the same line who have effected

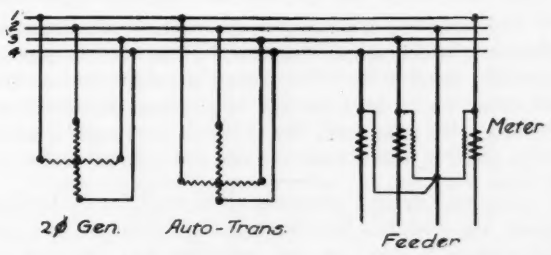


FIG. 35. METERING THREE-PHASE, THREE-WIRE AND TWO-PHASE, FOUR-WIRE POWER ON ONE THREE-ELEMENT METER

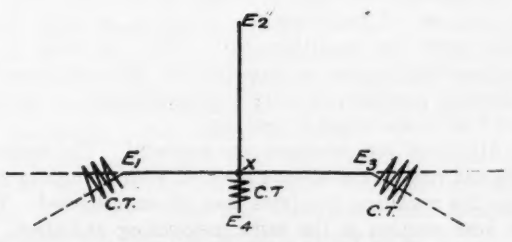


FIG. 36. PHASE RELATIONS OF CURRENTS AND VOLTAGES THROUGH METER SHOWN IN FIG. 35

the change may draw three-phase, three-wire power, while others not yet changed over may continue to use the old two-phase four-wire power. The problem then is to meter these composite feeder lines on a single meter.

Both forms of power may be obtained from the existing two-phase four-wire generators by means of autotransformers as shown in Fig. 35. The energy going out to both classes of users may be readily measured by one three-element meter connected as shown in this figure.

Analyzing these connections, it will be observed from Fig. 36 that the right-hand element of the meter is connected in line 1 while the corresponding potential element is connected across lines 1-2.

The three-phase component of the current in line 1 is then measured with the voltage E_1E_2 while the two-phase component of the current is measured with the component of E_1E_2 which is in phase with it, or E_1X. The torque of the right-hand element is therefore proportional to one-half of the total three-phase power plus one-half of the two-phase power in phase E_1E_3.

Similarly the middle element of the meter experiences a torque proportional to the remaining half of the three-phase power plus the remaining half of the two-phase power in E_1E_3, the latter using the in-phase component E_3X of the line voltage E_3E_2. In other words, the right-hand and middle elements register the total three-phase power plus the total power in phase E_1E_3 of the two-phase power.

Since there is no three-phase component of current in the leg marked E_4 the current transformer in this leg carries only the current of the phase E_2E_4 of the two-phase circuit and this power is measured on the left-hand element of the meter with the voltage E_2E_4 of the two-phase circuit. The left-hand element therefore measures the total power in the remaining half of the two-phase circuit.

Summarizing we find that the

Right-hand	element measures	0.5	3-phase power	plus	0.25	2-phase power
Middle	element measures	0.5	3-phase power	plus	0.25	2-phase power
Left-hand	element measures				0.5	2-phase power
Total		1.0	3-phase power	plus	1.0	2-phase power

The foregoing is strictly in accordance with Blondel's Theorem, which states that an N-phase circuit may be correctly metered by (N-1) meters provided the common potential point is taken at the phase which is not metered. In this case, the common potential is taken from phase 2, which does not run through the meter.

ALL THROTTLING processes often used for controlling steam are wasteful, for although they cause no heat loss they cause a drop in the pressure and decrease its ability to do work. Sometimes this throttling is deliberate as in the case of a turbine or engine where the loss is counterbalanced by some gain in operating results.

Sometimes throttling is through a reducing valve for the purpose of reducing the pressure, so that it will better serve the conditions to be met. At other times, the throttling is due to pipe friction, also evidenced by a drop in pressure, or wiredrawing through a valve or port that is too small or leaking.

All throttling processes are wasteful. The temperature and pressure is always lowered even though in some cases the resulting products may be superheated. True the heat content is the same, neglecting radiation, but the availability of this heat content or energy for conversion into work is reduced.

Refrigeration in Industry

By GEORGE E. WELLS

ONE OF the early developments of refrigeration was in connection with the brewing industry and the most important application up to the present time is in the manufacture of ice, which has had a steady growth over a period of more than 30 yr. and has achieved the position of one of the leading industries.

For many years ice making had but little competition. I think it was about a dozen years ago when the smaller refrigerating machines began to make real inroads in the larger markets, and stores of the country and, during the past 7 yr. there has been a steady increase in the number of small household machines. Even with the present competition, ice making has continued to grow, one reason, no doubt, being that extensive advertising of refrigeration has benefited the business of marketing manufactured ice as well as the small machines.

Refrigeration is taken as a matter of course in connection with the storage of food supplies and it is doubtful if our present civilization could even exist without this modern development. Quantities of dressed meat, poultry, eggs, fruit, dairy products, etc., are collected and properly prepared for consumption, then stored under refrigeration until such time as they are needed. Naturally, the markets where these goods are sold to the consumer must be equipped for refrigeration and the individual homes must to a smaller degree also be equipped for cooling. Cars used in transporting these commodities must also be refrigerated and, incidentally, a great quantity of ice is still used for this purpose. We see, therefore, a continuous use for refrigeration from the time of harvest to the time of consumption, often a lapse of many months.

Employment of very low temperatures for freezing various articles of food and bringing them to the consumer in more perfect condition has developed. It has been discovered that many food articles when frozen at temperature as low as —50 deg. F. are preserved in almost perfect condition, the reason advanced being that the cells are not ruptured at this low temperature and the result being perfect preservation. This method has been successfully adopted for fish and meats and successful experiments have been made with certain fruits and vegetables.

In order to develop this system of food distribution, many other refrigerating problems must be worked out. Markets must be equipped for handling such low-temperature commodities and, probably, the household equipment will be changed and improved to receive low-temperature foods.

Manufacture of so-called dry ice is another development of importance. This is prepared from liquefied carbonic acid gas which is solidified by expansion. This solidified CO_2 is then pressed into a solid mass, which has a low temperature approximately —110 deg. F. and gets the name dry ice from the fact that when melting occurs, the CO_2 evaporates leaving no moisture or residue from melting. This substance plays an important part in connection with the distribution of very low-temperature products, some commodities being refrigerated during shipment with solidified CO_2.

As to other industries, the enormous iron and steel industry utilizes refrigeration in its processes. Chemical manufactures having need of low temperatures install refrigerating equipment. Manufacturers of confections and pastry find refrigerating equipment indispensable. The oil refining industry is one of the most extensive users of refrigeration. For many years paraffine has been extracted from the crude oil by refrigeration, and late developments in the refining of nitrates utilize refrigeration.

Probably the most extensive recent development of refrigeration is in connection with air conditioning of theaters, public halls and other places where people congregate in great numbers. Cooled air for theatres seems to be a necessity in these days. The public probably does not realize the magnitude of some of these installations used for air conditioning. Engineering plans for refrigerating equipment for one auditorium recently called for refrigerating equipment in excess of 400 t. capacity. Almost every modern hotel is equipped with cooled and conditioned air for dining rooms and public assembly rooms and in fact there are few modern buildings of any kind that do not install refrigerating equipment of some kind. Design of air conditioning plant calls for knowledge of heating, ventilating and refrigeration, as it is the proper combination of these factors that go to make the properly ventilated building.

Some development has been made in public refrigerated pipe line constructions. With this system the customer buys refrigeration just as he buys water or electric energy.

In almost every new building installation refrigeration plays a part. In a modern factory building cold water is circulated and probably some portion is refrigerated. In every hotel, hospital, public building and home, refrigeration has some part and present indications are that the use of refrigeration will increase continuously. We do not know in just what form this increase will take place but the ability to control temperature is so well understood and is in such general use that we may reasonably expect this development to expand greatly in the future.

Handling Fuel Oil for Maximum Safety

BEST METHODS TO GIVE CLEANLINESS AND AUTOMATIC OPERATION. BY F. L. BURCKHALTER*

THIS ARTICLE deals primarily with the handling of crude oil for locomotive use as practice by the Southern Pacific Co. Other installations for handling of inflammable fluids with a flash point below 30 deg. F. and handling of Diesel oils for commercial uses, are made by the various industries, using their own standards of construction. Such installations are limited to locations on spur tracks at least 39 ft. from the nearest track over which passenger trains are moved. Stations handling liquids with flash point under 30 deg. F. are required to have the spur track insulated from other tracks, the rails bonded together and grounded to the industry's piping system to avoid trouble from static electricity.

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Serving of crude oil to locomotives by gravity flow from elevated tanks is no longer considered good practice and such systems are being replaced as rapidly as conditions permit with underground tanks and dual pump installations which deliver oil from underground tanks to the locomotive tenders through 8-in. oil columns.

Up-to-date plants have a spur track with 20-in. dia. by 42-in. deep sheet metal dump sumps, set vertically on the track center at 45 ft. intervals, flush with the top of ties. Cars are spotted over these sumps and a light 7-in. diam. sheet metal pipe is lifted from the sump and hooked to the car frame to prevent whipping of oil by the wind. The valves on top of the car are then opened and oil flows by gravity to the track sumps and thence through 12 and 14-in. pipes to an underground concrete tank of approximately three-car capacity. These underground tanks are constructed to conform with the various city and state laws governing such installation and in accordance with rules outlined by the National Board of Fire Underwriters.

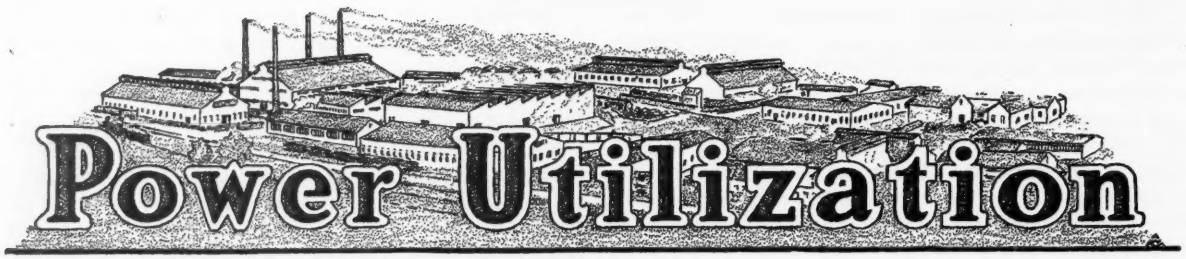
From the underground sump the oil is pumped either to the column or to large steel storage tanks, of 5000 to 55,000 bbl. capacity, which rest directly on the ground or gravel mat within a levee of sufficient size to impound one and one-half the capacity of the storage tank. This prevents the spread of fire in case of tank break from lightning. The storage tanks are also protected from evaporation and fire by pontoon roofs floating on the oil surface. After cars are emptied, pumping of oil to the storage tank is stopped and the underground tank is left full of oil for column service. The oil served to columns is automatically replaced by gravity flow through a hydraulically controlled valve on the line from the storage tank. Oil in the underground tank is heated by steam to a temperature of 120 deg. F.

The pumping plant is made up of two interchangeable 400-g.p.m. pumps, arranged by a piping manifold to allow one pump to stay on the column service at the same time the other is used for pumping to storage tank. Where a steam pump installation is made, the pump on column service is allowed to idle, keeping 25 lb. pressure on the column line and circulating hot oil through the 10 or 12-in. column line and back to the sump through a 3-in. return circulating pipe, the tap for return pipe being taken off in the column pit. This arrangement keeps the pipe line to column full of hot oils, keeps the pump free from condensate and ready to start at full delivery when the column valve is opened.

Where electricity driven rotary pumps are used on column and storage tank service, a small duplex pump is used for circulating the oil. The electrically driven pumps are operated either by start and stop push button at the column or by pressure governor with remote control to a starting panel.

A very novel arrangement for shutting down all pumping operations and shutting off the flow of oil from the storage tank has been devised. These operations are accomplished automatically by breaking an electric contact should a column be pulled over, or manually by breaking of a glass in any fire alarm box located at convenient points about the yard.

The first cost of such installation is much higher than the old time gravity tank systems; but from the standpoint of safety from fire, cleanliness and automatic operation, the first cost is but a minor item.



Economy of Proper Industrial Lighting

REDUCED ACCIDENTS AND SPOILAGE AND INCREASED OUTPUT RESULT FROM PROPER INTENSITY OF LIGHTING AND FREEDOM FROM GLARE. BY ROBERT L. ZAHOUR*

AMERICAN industry is undergoing readjustment. Industrial executives are analyzing methods of modern factory management and are utilizing every possible solution which enables them to operate more economically. Plant superintendents, with surplus stocks on hand, are probably less interested in greater production than in means of improving the efficiency of workers, thereby reducing manufacturing costs. Artificial illumination of high intensity, of even distribution, and without glare will help to accomplish this. By lessening eye fatigue alone, it increases the personal efficiency of a worker; not to mention the guard against accidents by improving his speed and accuracy of vision. Experience shows that every dollar invested by a manufacturer for improved industrial lighting brings an annual return of $34—quite an economy of proper industrial lighting.

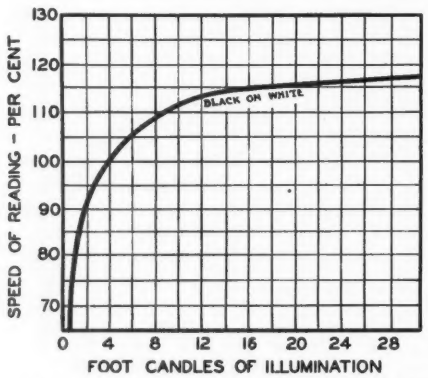


FIG. 1. GOOD LIGHTING SPEEDS UP VISION AND PROMOTES ACCURACY

ACCIDENTS REDUCED

Industrial accidents, due to improper lighting conditions, create one of the greatest economic wastes in American industry. According to the National Safety Council, 23,000 fatal accidents and 300,000 non-fatal accidents occurred in 1929. Based on the estimates of the U. S. Bureau of Labor Statistics, the cost of these deaths and injuries totaled approximately one billion dollars. Fifteen per cent of these casualties were traced directly to faulty lighting conditions. On this basis, an industrial accident occurred in the United States every 23 sec. because of improper lighting. Each day at least 12 fatal accidents might have been prevented by correct lighting.

It should be remembered that the cost of accidents involves not only the injured workman's compensation, (20 per cent of which is paid by insurance companies and 80 per cent unconsciously borne by the manufacturer), but losses due to idle machines, the instruction of new employes and the necessity that experienced workers leave their tasks to train green men.

Economical production depends largely on a minimum of spoilage. If the workman can see easily and quickly, he is less likely to spoil product by inaccurate turning or fitting on a piece of equipment. Tired or defective eyes detract from accurate work. Good lighting, which literally removes a blindfold and enables the workman to visualize at normal speed, reduces eye fatigue, resulting in better quality of workmanship and reduces spoilage in manufactured product. Dim lighting also makes moving machinery appear to be moving more slowly than it actually is, a condition often causing unnecessary accidents due to misjudgment.

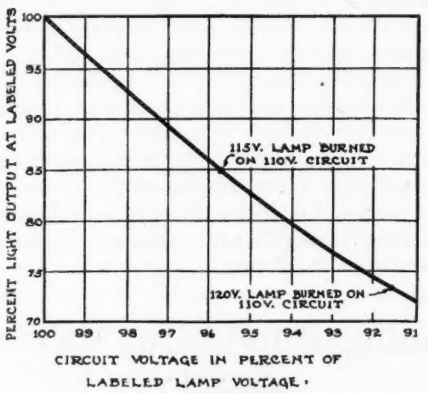


FIG. 2. OVERLOADED CIRCUITS CAUSE VOLTAGE DROP AND REDUCED LIGHT OUTPUT AS SHOWN FOR MAZDA LAMPS

INADEQUATE WIRING IS COSTLY

Too often a building is wired to meet the immediate lighting requirements of a tenant, with no provision for possible future demands. A warehouse, receiving room, or shipping area may be lighted with a few low-wattage

*Electrical Engineer, Westinghouse Lamp Co.

lamps spaced 15 or 20 ft. apart to provide sufficient illumination for the rough work but, if at a later date it is desired to use the same area for a machine shop, a drafting room or an office, additional illumination will be necessary.

Tapping existing circuits for additional lighting units and increasing the lamp wattage throughout does not always remedy the situation. Instead, it can make conditions worse. The power required for additional units and the increased lamp wattages quite frequently overload the lines, causing excessive voltage decrease and even a slight heating of conductors. An appreciable voltage drop also occurs between the panel board and sockets, decreasing the maximum economical light output of the lamps. Furthermore, branch circuits with "tacked on" sub-branches make it difficult to obtain a flexible or convenient switching arrangement for particular areas or sections where artificial illumination is necessary on cloudy days.

Apparently, rewiring and reallocation of outlets and switches is the only solution to provide a satisfactory lighting installation where the old system is inadequate. Now is the time to rewire adequately or plan ample wiring capacity for new structures, for the prices of copper and rubber are today the lowest they have been since 1902.

Plan Lighting System First

Like any machine design problem, the ultimate requirements of a lighting installation should be analyzed and planned before considering the size of wire in branch circuits and feeders. In the lighting of ordinary commercial or industrial areas, the probable maximum demand would suggest the use of 500-w. Mazda lamps spaced on 10 or 12-ft. centers. This general spacing of outlets will meet the location requirements in shops, drafting rooms, general offices or retail stores.

An excellent example of the value of such a flexible arrangement is shown in an accompanying illustration, a large floor area in an industrial plant. The outlets are spaced on 10-ft. centers and wired to accommodate 500-w. lamps. For a period of 2 yr., this section was employed for warehouse storage, and only the alternate rows of units, equipped with 150-w. lamps, were used for lighting purposes. Expansion in manufacturing activities forced the tenant, whose shops already occupied the lower floors, to convert this area into an additional

FIG. 3. THIS AREA WIRED FOR 500-W. LAMPS WAS EASILY CONVERTED FROM WAREHOUSE TO MACHINE SHOP

shop. Since the lighting intensity for a machine shop should be at least four times that considered satisfactory for warehouses, every one of the units was put into service with 200-w. white bowl Mazda lamps, resulting in an excellent system at no additional wiring cost to the owner.

Recommended Wiring Capacity

In sections where 15-amp. at 110 v. fusing of branch circuits is permitted, the loading per circuit of the initial installation in a commercial or industrial interior should be not over 1000 w. A branch circuit should supply the lighting load for a rentable area of work space not greater than 400 sq. ft., or for an equivalent bay approximately 20 by 20 ft. No branch circuit should supply the lighting load for more than 800 sq. ft. of hall space, passageway, non-rentable or non-productive area.

In all branch lighting circuits, runs from panel board to first outlet should be provided with wire of not less than No. 12 B & S gage size; runs of 50 to 100 ft. from panel board to first outlet, not less than No. 10 B & S gage wire; and for runs between outlets, not less than No. 12 B & S wire. Whenever possible, runs exceeding 100 ft. from the panel board to the first outlet should

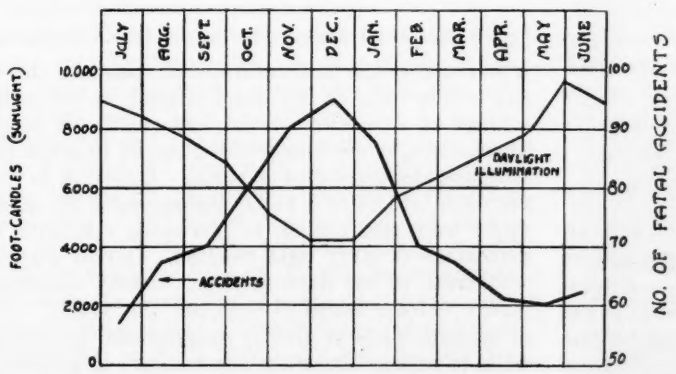


FIG. 4. ACCIDENTS INCREASE IN SEASONS WHEN DAYLIGHT IS INADEQUATE

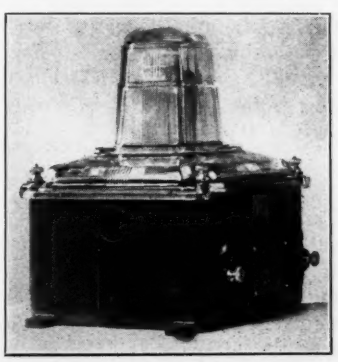


FIG. 5. PHOTO-CELL RELAY FOR AUTOMATIC CONTROL OF LIGHTING

be avoided; provide additional panel boards or relocate present ones. Where, however, such runs cannot be avoided, the initial lamp load should be limited to 600 w. per circuit and wire not smaller than No. 10 B & S gage should be used between the panel board and first outlet.

No convenience outlets should be placed on any circuit supplying overhead lighting outlets. For convenience, wall or baseboard outlets should be of the duplex type and not more than six of these should be placed on one circuit. Use not smaller than No. 12 B & S gage wire, where the run from panel board to

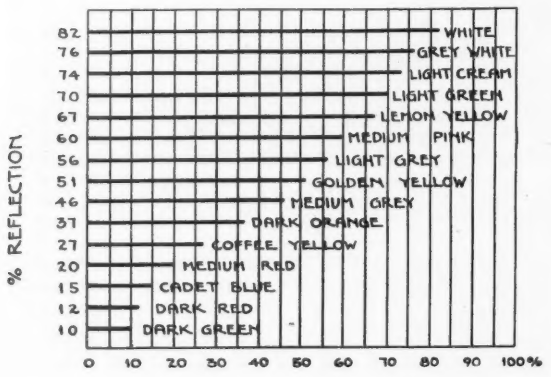


FIG. 6. WHITE AND LIGHT SHADES OF GREY, CREAM AND GREEN REFLECT LIGHT BEST

first convenience outlet is under 100 ft., not smaller than No. 10 B & S gage wire where the run is over 100 ft.

It is recommended that conduits for enclosing feeder wires should be of sufficient size to allow replacing the original feeder, if future expansion demands this alteration. A feeder at least two standard B & S gage sizes greater in capacity will suffice for this purpose.

In localities where 15-amp. fusing at 110 v. is permitted, the feeders on every branch circuit, including spares, should be of such size that the voltage drop from the service entrance to the panel-board will be 1½ per cent or less, with a load of 10 amp. at 110 v. Where a local electrical ordinance limits the permissible load per circuit to less than 10 amp. at 110 v., the initial loading per circuit should be proportionately reduced.

Panel boards for controlling lighting circuits should contain a minimum of one spare circuit position for at least every five active circuits. Every floor of the building should have its own panel board, which should be located so that branch circuit runs to first outlets will not exceed 100 ft.

Economic Light Control

Failure to supplement inadequate daylight with artificial illumination is another cause of industrial accidents and increased spoilage. Invariably, the gradual fading of natural illumination on cloudy afternoons and particularly during the short days of the winter months, escapes the attention of the shop foreman or one in charge of lighting control. This fact coupled with that of improperly designed lighting systems results in an increase in accidents, most of which occur in the winter months. When the sky clears, thus increasing daylight illumination, after the artificial lighting system has been turned on, the lights are left burning when they are not needed and power is wasted.

To prevent such inefficient light control, an automatic photo-cell device, Fig. 5, is recommended. It will automatically switch on the lights when daylight falls below a pre-set intensity and extinguish them as natural illumination increases above this value.

For safety and convenience on entering or leaving a shop after dark, the lighting control panel should be located near the entrance door as the exit light there will provide sufficient illumination for operating switches after all lights have been turned off. A further economical practice especially for night operations, is the systematic control of lighting units, one bay of four units being connected to one tumbler switch on the

FIG. 7. ILLUMINATION CHECKED PERIODICALLY

FIG. 8. MAINTENANCE TRUCK SAVES LABOR

panel board. This flexible wiring and control arrangement permits use of lights only in sections where working operations are actually going on, thus eliminating waste of unnecessary lighting.

Light Colored Interiors Return Stray Useful Light

Since the color and nature of the paint on the walls and ceiling have an important bearing on the ultimate wattage of a lighting system and quality of resulting illumination, much consideration should be given to the reflection characteristics of paints. Referring to Fig. 6, flat white mill paint is highly recommended for finishing upper walls and ceiling, as this shade returns a large percentage of stray light received. Darker shades absorb much of the light received, thereby necessitating higher wattage lamps to overcome the waste. A light or medium shade of gray is recommended for the lower walls to subdue unsightly finger-marks or general wall marks. White or light cream is recommended for the upper walls and ceiling. Avoid use of high glosses or varnishes, as they cause a peculiar reflection and glare.

Illumination furnished by a new lighting installation is from 25 to 50 per cent higher than the average illumination furnished by the same installation after it has been in service for some length of time, due to the unavoidable collection of dust and dirt on the lamp and reflector equipment. It is impracticable to maintain lighting equipment constantly in its original dirt and dust free condition but it is also uneconomical to allow this dirt accumulation to decrease materially the illumination for long periods. In the average industrial interior, it is essential that the lighting equipment be cleaned with a dry cloth at least once every three to four weeks. At about every third cleaning, it should be thoroughly washed with soap and water, rinsed in ammonia water and thoroughly dried. One-half pint of household ammonia to every 4 gal. of water gives a good cleansing solution. Lamp bases should not be immersed in the cleaning solution or water. All burned out lamps should be replaced by lamps of the proper wattage and voltage, because one bad lamp reduces the efficiency of a lighting system more than the laborer is wont to believe.

The electrical department in every industrial plant should keep running records of the illumination intensities obtained with a foot-candle meter, Fig. 7, in various parts of the plant so that regular cleaning schedules can be arranged. To save time and labor for the maintenance of lighting equipment in plants of large areas, the use of a lift truck and platform provided with a ladder, cleaning equipment, record books, spare lamps and reflectors, is recommended. As soon as lighting intensities fall below established levels, the reasons should be determined and the intensity restored.

Welded Heat Storage Tank

By Dr. Ing. Carl Commentz

HAMBURG Electrical Works, which not only delivers electrical current to that city, but also owns a large central heating plant, by which a large number of office buildings and public buildings is heated by hot water has of late put up a hot water tank of 2650-t. water capacity, which is to serve as a heat accumulator. Heating of hot water and generation of electricity are on a combined basis so that water is heated by the exhaust from a counter-pressure turbine plant. As a matter of fact, the hot water is the main output of this plant and electricity is a byproduct only.

Demand for heat varies considerably not only with the season but also during the day; it is largest in the morning, soon diminishing when the buildings are heated up and the outside temperature rises. Because of this, not only has the load on heating boilers been irregular but also the generation of electricity, which naturally influenced the heating costs adversely. By the installation of the heat storage tank, Fig. 1, which has a diameter of 30 ft. and a height of 115 ft., it will be possible in winter to keep the heating boilers as well as the turbines for generation of electrical current under steady load nearly all day. Thus both heating and electrical plants will be much better used and their all day capacity increased.

At the time of night electrical peak, the counter-pressure can be taken from the turbines, so that the

FIG. 1. HEAT STORAGE TANK 30 BY 115 FT. TO STORE 33,000 KW-HR.

plant will be used primarily for generating electricity. The new tank has been built so large, that it will be able to take up not only the heat from the existing plant but also that from an extension in which will work a large high-pressure boiler plant with 1400-lb. pressure and with a counter-pressure turbine of 20,000-kw. capacity, in total a heat storage of 33,000 kw-hr.

Contracts have been made to heat in future a number of large buildings, which have until now had their

FIG. 2. REINFORCEMENT ON THE EXTERIOR OF HORIZONTAL AND VERTICAL SEAMS AND BY TEE BAND HOOP

own heating systems. For this purpose, it has been necessary to lay large insulated pipe lines through the main streets of the city. The tank has been put at the center of the heated district, about 900 yd. from the heat and power-generating plant. It is sufficient for 5 hr. heating of the system without getting new heat from the station, the water being heated up to 130 deg.

As the tank serves not only to store the hot water before it goes to the buildings but also the returning cold water before it goes back to the power station, there is mostly cold water in the lower part and hot in the upper, the relation varying over a large range. In order to regulate the water quantities, inlets for return water have been provided at three different heights. The outlet for hot water is at the top and the inlet and outlet for cold water are at the bottom of the tank. The cold and the hot water are separated by an insulated platform, which is raised or lowered in accordance with the relation between hot and cold water volumes.

This tank is interesting not only as one of the largest heat storers in the world, but because it has been built up entirely by electrical welding. As no other place is available in the center of the district, the tank had to be erected in the court of the administration building of the Hamburg Electrical Works, which is small and this accounts for the unusual dimensions of the tank. Great height in proportion to the diameter is unfavorable as concerns construction costs, insulating the surface and the bottom pressure resulting.

Surrounding the court are large office buildings, hence noise had to be avoided in the construction, so that only welding could be utilized. It was difficult to weld the long and in places rather thick seams without disturbing heat effects, even though electrical welding was used. The tank was built upon a steel-concrete foundation, 6 ft. thick. The bottom plates are 0.4 in. thick; the lower side plates have a thickness of 0.8 in., the uppermost of 0.25 in. There are in total 20 tiers of circular sheets each 6 ft. high. Welding was effected by V-seams from the inside, the outside being strengthened by welding laps across the seams, Fig. 2, and the lower part reënforced by bands of T-steel.

Construction of the tank involved welding about 2200 yd. of seams, requiring 2½ t. of electrodes. Five months were necessary for the erection of the tank but, when it was tested with cold and hot water, no defects were found except some minute leaks through which only small water drops came.

Exhaust Steam Economy

HEAT OF EXHAUST STEAM FULLY UTILIZED SAVES LIVE STEAM. PROOF FROM A WOOD-WORKING PLANT. BY L. A. CORWIN*

ONE OF THE first questions likely to be asked of an engineer in charge of the average industrial plant is, "What do you use your exhaust steam for?" And the next, "Do you use it all?"

Although this situation often presents itself, how many engineers responsible for the cost of power and operation of their respective plants give thought as to just how much more this exhaust steam could do.

About a year and a half ago, it became necessary to increase our lumber drying capacity. Exhaust steam was sufficient and satisfactory for the present but just what would happen, if we were to extend the kilns to get additional heating was one problem; another that presented itself, would future business warrant this proposed kiln extension expenditure? The whole matter was readily solved after a year's investigation and experimenting, by installing a kiln control.

AUTOMATIC HEAT CONTROL

This device was applied to all the kilns, eleven in number, with the result that 23 per cent more lumber was obtainable by reducing the time of drying, 18 per cent less exhaust steam was used and this saved steam was directed to different processes within the manufacturing plant, eliminating live steam entirely while operating machinery. Also 37 per cent less live steam was used to maintain these kilns after operating hours.

In this equipment, each kiln has its individual control of humidity and dry heat. Lumber is piled on trucks, placed in the kilns and the doors then closed. After a drying schedule has been prepared, according to thickness, size and kind of lumber, the instruments have the charts placed for the starting time of drying, the controls for temperature are set and the drying proceeds. Each day samples are taken and tested to ascertain percentage of moisture of air and lumber.

EQUIPMENT AND OPERATION

Operation of this particular control is effected in the following manner. Arrangement of power house and connections to kilns are shown in Fig. 1, construction of kilns in Fig. 2 and details of control valve arrangement in Fig. 3, all sketches being diagrammatic.

Exhaust steam being admitted to the 10-in. main supply line, proceeds to the kiln or kilns that are to be operated. Valves are under automatic control and operate only when the bulbs located within the kiln where the lumber is placed, permit the opening and closing. Valves are operated by air pressure, Fig. 3, which, in turn, is controlled by temperature as registered by the wet and dry bulbs. Controls are adjustable for the temperature at which the kiln is to be maintained and carry circular charts to record temperatures maintained. The plant is otherwise well equipped with recording instruments, sample records being shown in Fig. 4 for kiln temperatures, exhaust and live steam supply pressure, vacuum maintained and temperatures of makeup water and feedwater.

After test has been taken of the lumber for moisture content, the first procedure is to set the dials on the temperature chart for the correct amount of temperature and humidity. After this is done, air is admitted to the instruments to control valve operation on the

*Chief Engineer, The Milwaukee Chair Co.

distribution of steam for that kiln. An auxiliary valve in the control instrument checks the flow of air according to the temperature of the bulbs in the kiln; it has been set, as stated, for the desired temperatures. Should the temperature fall, the auxiliary valve admits air to a diaphragm-operated valve on the line to the steam-

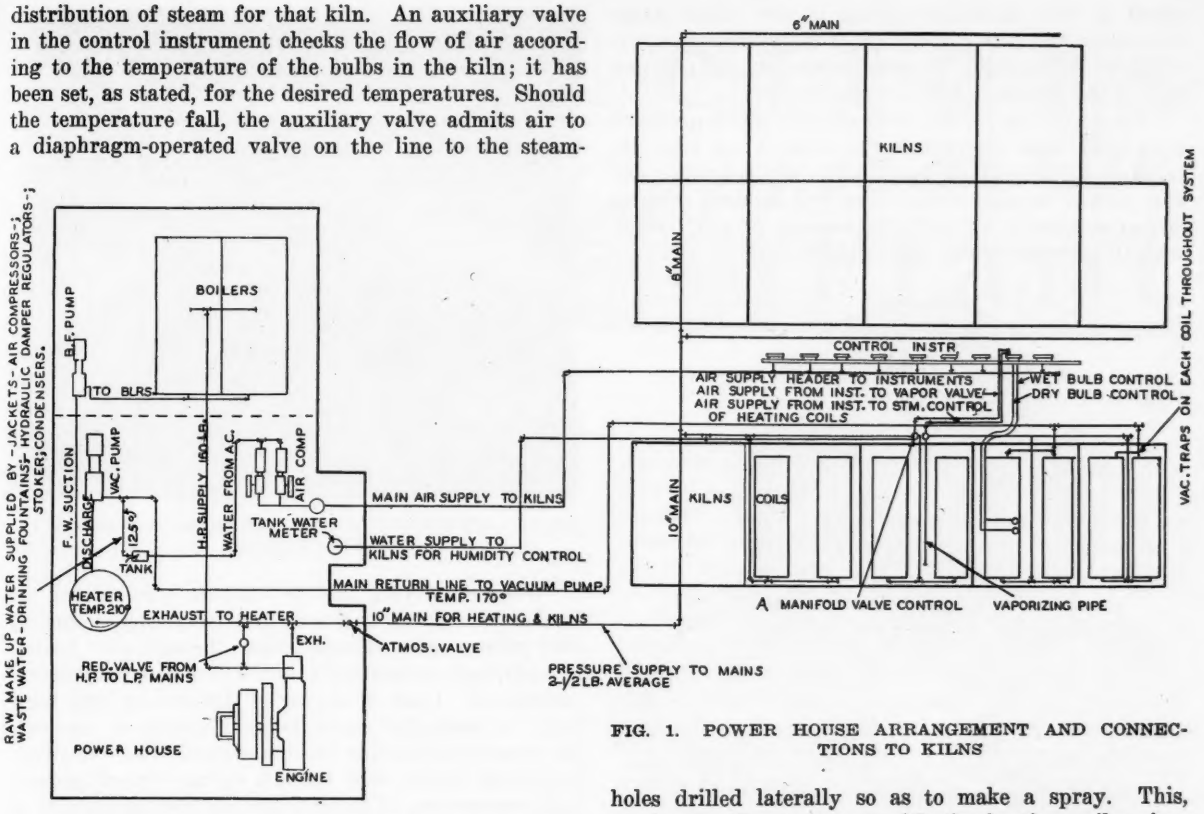


FIG. 1. POWER HOUSE ARRANGEMENT AND CONNECTIONS TO KILNS

heating coils, opening it just enough to raise the temperature again and then letting it close. Likewise, the wet bulb permits the flow of free steam to the kiln through a section of 3-in. pipe, closed at one end, with holes drilled laterally so as to make a spray. This, coming in direct contact with the heating coils, gives the proper amount of humidity.

The wet bulb is kept continuously moist by water that is filtered through stone water filters so that the water is practically 95 per cent pure and there is no possible danger of clogging of the wet bulb, as that would permit no moisture in the kiln and result in "checking" or case hardening of valuable lumber.

Each coil and dead end of pipe line is equipped with a Sarco high-vacuum trap. Vacuum of 25 in. is main-

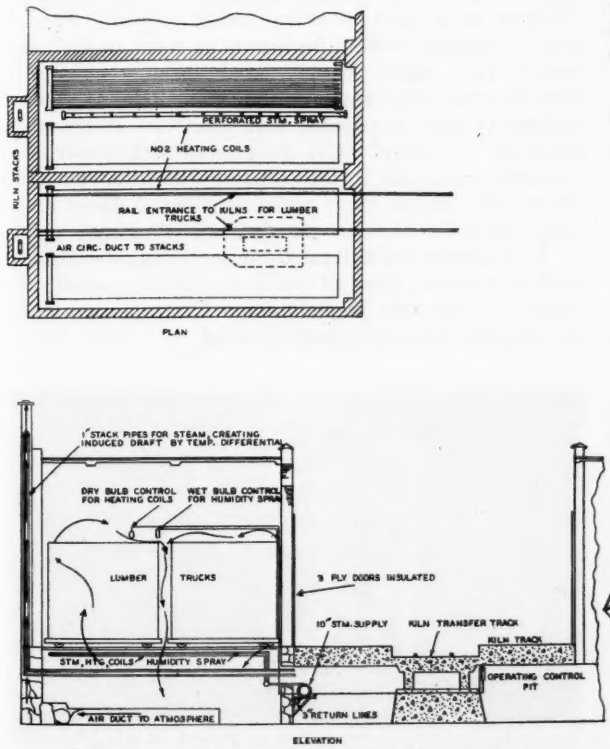


FIG. 2. PLAN AND ELEVATION OF KILNS

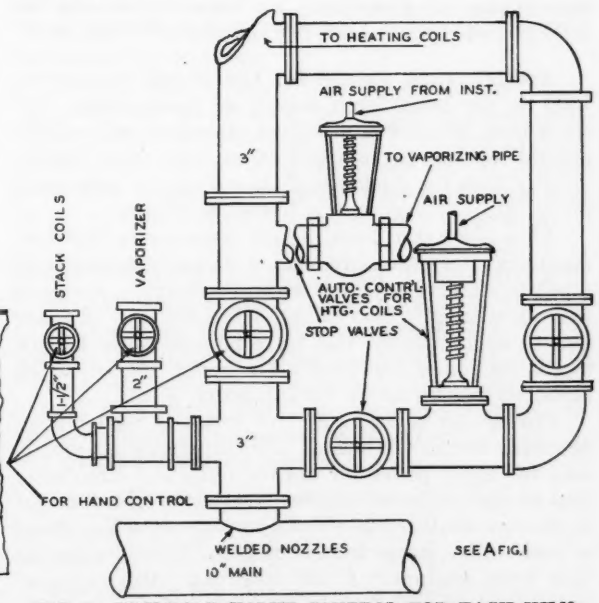


FIG. 3. MANIFOLD VALVE CONTROL FOR EACH KILN

tained on this particular system to give rapid steam circulation and better operation of the automatic equipment by maintaining constant temperatures, not permitting the system to load up with water.

Air circulation for the lumber in the kiln is produced by a steam coil, inserted in the stack of the kiln; the relative differential afforded between atmosphere and heat within the kiln creates a natural induced draft so that circulation is effected, the amount of draft being regulated by hand with damper provided.

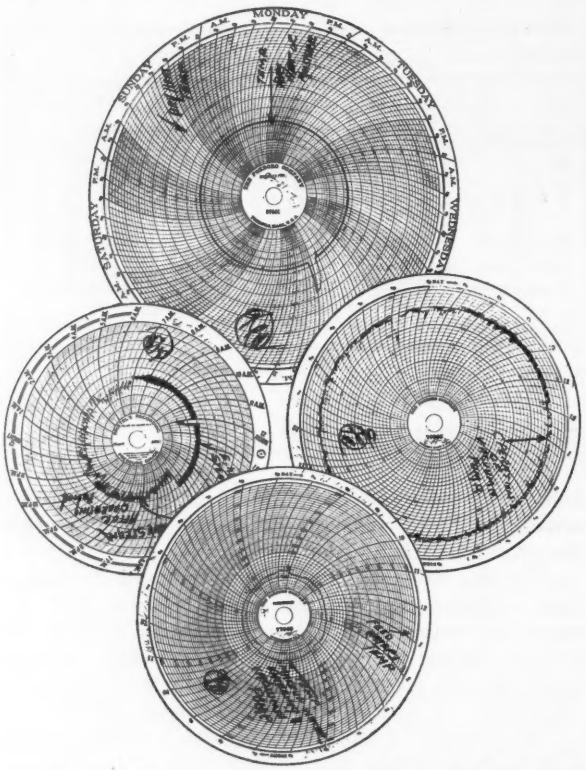


FIG. 4. CHART RECORDS OF OPERATION. A, KILN TEMPERATURES; B, PRESSURES AT KILN; C, VACUUM ON RETURNS; D, WATER TEMPERATURES IN POWER PLANT

Average steam utilized for kiln drying amounts to 7300 lb. per hour, for a battery of eleven kilns. All condensate from the kiln heating system as well as from general heating, is returned to an open type heater, directly from the discharge of the vacuum or condensate pump, at 135 deg. and is heated to 210 deg.

All waste water from the air compressors, drinking fountains, stoker condensers and damper regulators is piped to an auxiliary tank whose discharge is equipped with an automatic float valve. When the level of water gets to tank capacity, this valve permits water to flow to the suction of the condensate pump, thence to the heater so that no direct makeup water is used.

During the summer, no live steam is used during operating hours. In winter, a small generating unit is used to supply power for heating units and circulating fans so that sufficient exhaust steam is obtained except in sub-zero weather when about 10 per cent of live steam is used. Live steam is also used for kilns during the time when machinery is not operating. Otherwise exhaust steam is used entirely for kilns and process work.

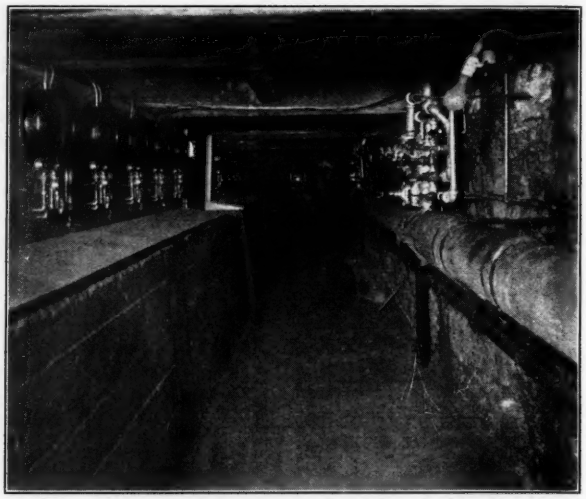


FIG. 5. INSTRUMENTS AND CONTROL VALVES IN PIT BELOW KILNS

When the drying time or schedule is completed, the lumber is removed and sent to a tempering or cooling shed where again exhaust steam through unit heaters is controlled automatically and a constant temperature maintained. Costs of drying of lumber are kept regularly, a steam-flow meter being installed to ascertain the steam consumption of both exhaust and live steam. Recording charts show vacuum on the return systems, also temperature of water from the heating returns so that an integral interlocked system is kept on the utilization of exhaust steam as well as on steam generated.

All instruments are mounted on a control board in the subway or operating pit beneath the kilns, carefully lighted and erected so as to be operated with the same efficiency as a plant of prime mover capacity, Figs. 5 and 6. Regular weekly inspection is made to find any trouble that might possibly occur through operation. Kiln doors are kept snug, an important item, as greater leakage of heat is possible here than can at times be supplied. All steam mains are covered with 85 per cent magnesia insulation to the point of admission the coils. Steam coils and all other piping exposed to direct moisture within the kilns are painted with aluminum paint.

Instruments are calibrated for performance regularly each six months. Control valves are freshly packed each month so that they may function freely; water filters are cleaned daily and charts checked.

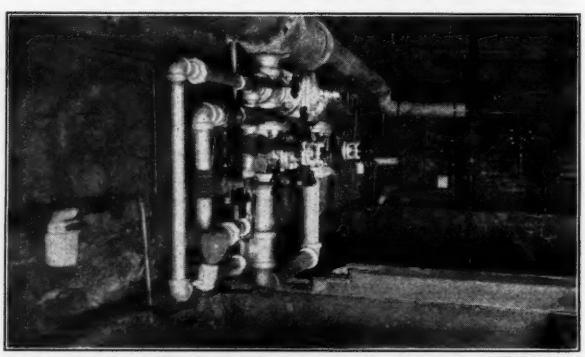
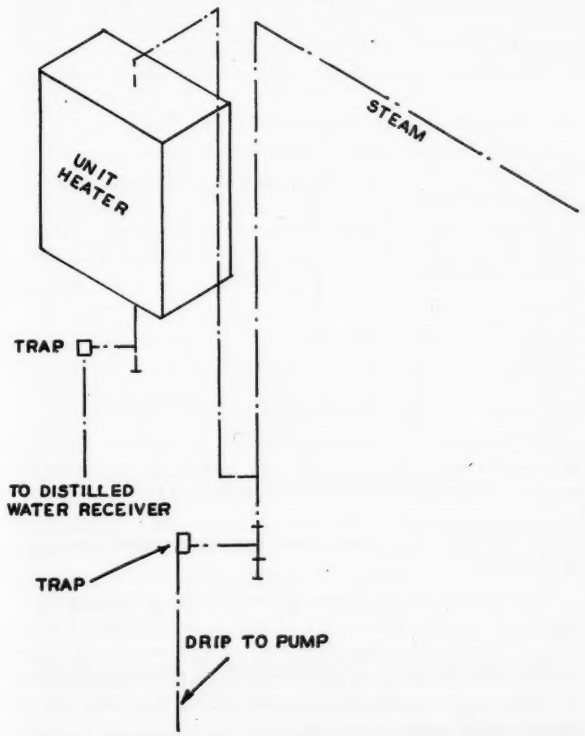


FIG. 6. CONTROL VALVE ASSEMBLY AND STEAM PIPING

Condenser in Commercial Still Line Removes Moisture

AFTER HAVING had considerable trouble with a "commercial still," we decided to build a condenser, using steam from our heating plant, as shown in the diagram



ARRANGEMENT OF CONDENSER IN CONNECTION WITH A COMMERCIAL STILL FOR REMOVING MOISTURE

layout. The steam from our boilers contains about 2 per cent moisture. In order to keep this moisture from impairing the quality of our distilled water, we built a separator which has worked well. To make this separator, we rolled up a piece of ¼-in. mesh galvanized wire netting and placed it in the pipe which rises to the unit heater, the trap below removing the water which the netting caught.

In calculating the size of unit heater needed, a rough rule, 4 sq. ft. of heater to condense one pound of water per hour may be used. This is true for saturated steam, having a pressure of about 5 lb. gage. The steam pipes should be covered to prevent condensation as much as possible. As the rate at which the unit heater will condense the steam is dependent upon the temperature of the air flowing through it, it is well to place the heater so that outside air may be drawn through it.

We have used this condenser for over a year and we have had good results. The water is of good quality and suitable for nearly all of our laboratory uses. The cost is less than 2 cents for 5 gal.

Wichita, Kans. JOHN GADDIS.

Stoker Plant Efficiency

AT PRESENT we are operating a plant with two 800-hp. and two 1000-hp. boilers, 155-lb. pressure, feedwater average 208 deg. For 8 hr. a day we run at a little over 100 per cent rating and get evaporation of 9.5 to 10 lb. from coal of 13,800 B.t.u. The CO_2 will run 12 to 14 per cent and efficiency 68 to 70 per cent. The balance of the day we run at load as low as 50 per cent of rating and get 5 to 9-lb. evaporation, CO_2 6 to 9 per cent and efficiency much lowered.

For light load, we have tried all kinds of firing, with about even results. Stokers are underfeed, from 7 to 13 yr. old. A fairly heavy fire will go into a partial bank when air is reduced; a light fire will go full of blow holes and CO_2 will drop.

I would like to hear from others having similar equipment and conditions as to whether they are getting better results and how they do it. We feel that our boilers are too large for the light load but are eager to know how to get better results during the light load period of 16 hr. a day. H. G. K.

How Do You Select Your Economizer?

MY ATTENTION has been called by Frederick T. Morse of the Louisiana Polytechnic Institute, Ruston, La., to the fact that equation III on page 1215 of the Nov. 1 issue, in my article "How do you select your economizer," is in error. The entire denominator of this expression should be multiplied by R, instead of only the first part. The correct form is

$$S = \frac{1000}{R\left(\frac{T_1 - t_1}{t_2 - t_1} - \frac{K+1}{2}\right)}$$

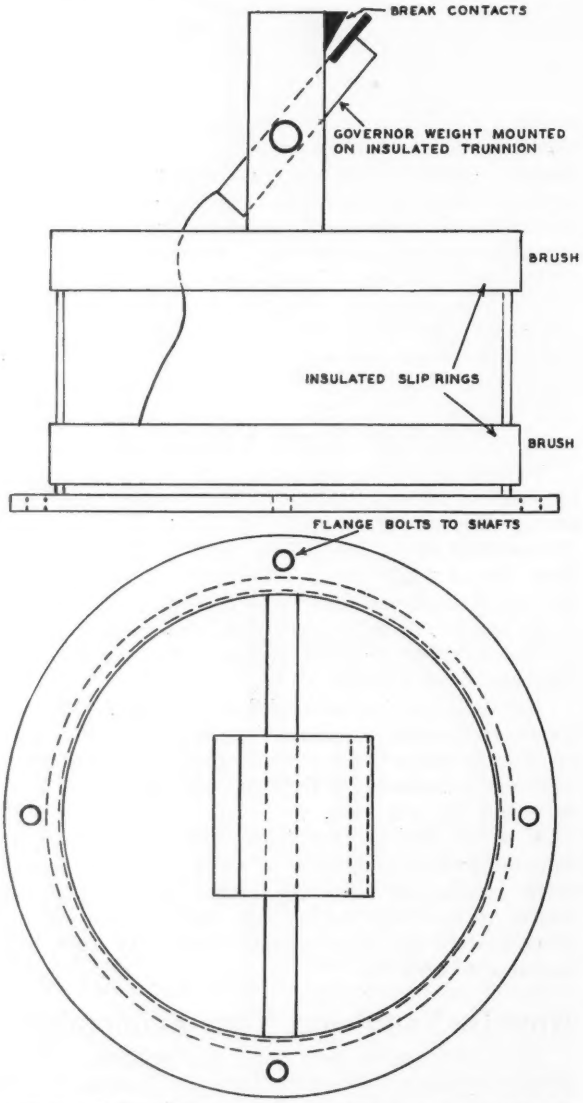
The curve in Fig. 3, however, is correct, as the correct formula was used in calculations. I believe this

method and form should be credited to the B. F. Sturtevant Co., from whom I learned it about 10 or 12 yr. ago and who, I believe, are the ones who originated it.

Cleveland, O. THEODORE MAYNZ.

Composition Contact on Governor Prevents Arcing

WHILE OPERATING an automatic hydroelectric station, I experienced trouble with a high-speed governor on an auxiliary unit. This unit was an impulse wheel



FUSING TOGETHER OF BREAK CONTACTS AVOIDED BY USING COMPOSITION CARBON-GRAPHITE INSTEAD OF SILVER FOR THE CONTACTS

direct connected to an alternating current generator and a gear pump serving the pressure system of the main servo-motors. The troublesome governor was mounted on a shaft extension of the pump and when the unloading device allowed the pump to force oil against the 150-lb. pressure of the oil system, a serious vibration was set up which caused a destructive arcing of the silver "break contacts." Several times the contacts fused together.

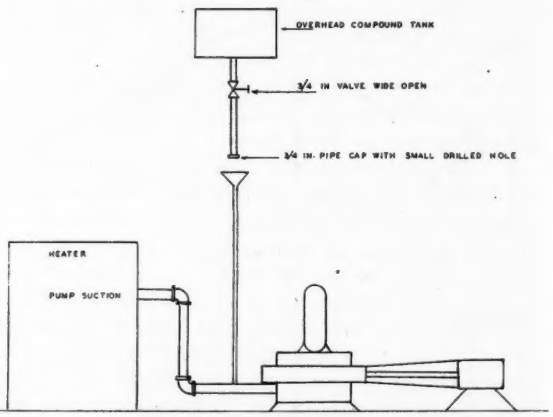
This trouble was entirely eliminated by replacing one of the silver contacts with one made out of a composition carbon-graphite brush. Experiments showed that the silver would not fuse to the composition nor be discolored. The function of the contacts was to complete the holding circuit of the master contactor of the auxiliary unit during normal operation and to open on a predetermined increase of speed, therefore it was not advisable to increase the spring tension on the contacts.

The arrangement illustrated has been in successful operation for more than a year and a half.

Angola, Ind. T. R. MORE.

Improvement in Boiler Compound Feeder

IN MANY SMALL plants, boiler compound is fed by gravity from an overhead tank into the boiler feed pump suction line through a valve which is cracked open.



CLOGGING OF PIPE AVOIDED BY OPENING VALVE WIDE AND DRILLING SMALL HOLE IN PIPE CAP

Much trouble is experienced by this valve becoming stopped up.

By using a ¾-in. pipe and valve and placing a ¾-in. pipe-cap on the lower end of the pipe, a hole of about ⅛-in. diameter having been drilled in the cap, the valve may be left wide open and much better results obtained. A little experimenting will determine the best size of hole to drill in the pipe cap.

Newcastle, Ind. NELSON HOWARD.

Expansion Operates Homemade Steam Trap—A Correction

IN THE DESCRIPTION of the automatic trap published on page 1297 of the Nov. 15 issue, the fitting used in the top opening of the tee should have been the bonnet which had been removed from the valve body.

With this arrangement, the fitting is steam and water tight but allows movement due to the expansion of the pipe.

Toronto, Canada. JAMES E. NOBLE.

Diesel Efficiency at High Speeds

SINCE THE frictional loss of a Diesel engine is considered to be constant for all speeds, why does the efficiency decrease when the engine is run at speeds much higher than that for which the engine was designed? This appears to indicate that Diesel engines should not run at high speeds, notwithstanding the apparent tendency toward high speeds. D. E. O.

A. While higher thermal efficiency may be expected in a properly designed Diesel engine operating at high speeds than when the same engine operates at low speeds, if the engine has not been designed for high speed, restrictions of valve operation will decrease the thermal efficiency if the speed is increased too much because of improper combustion and of inadequate scavenging of the cylinders.

At best, combustion is not instantaneous in an internal combustion engine and unless specific provision has been made for adequate diffusion of the charge and of proper ignition for the higher speed, combustion may continue throughout the entire power stroke instead of being completed early in that stroke, also some combustible gas may be discharged with the burnt products.

If the method of scavenging has not been designed for the higher speeds, it is probable that more of the burnt gases will be retained in the cylinder at the end of the power stroke at high speeds than at the lower speed for which the engine was designed. The burnt products retained in the cylinder not only displace some of the incoming charge but heat that charge, decreasing its heating value per cubic foot and, mixing with the fresh charge, will decrease the flame propagation of the charge adding to the loss of efficiency due to poor ignition and slow burning already explained.

A Diesel engine is best operated at its rated speed.

Action of Magnesium Chloride on Boiler Tubes

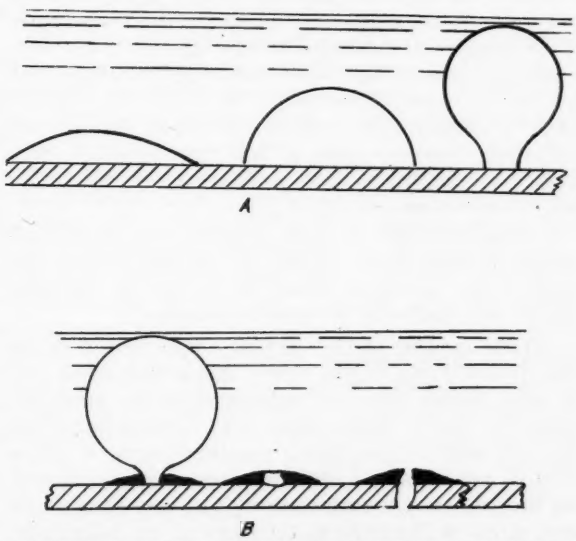
DOES MAGNESIUM chloride affect steel boiler tubes when they are steam locked? If so, in what way? E. K.

A. There is still some difference of opinion regarding the effect of magnesium chloride on boiler tubes but it is generally conceded that the developed acidity within a boiler, which is the most common type of boiler corrosion, is frequently caused by a peculiar action of magnesium chloride.

Magnesium chloride, in solution, does not attack steel, while corrosion is caused by contact with this material when it is in a dry state. Sir John Dewrance was the first to discover how this salt could be dry at the bottom of a steam locked boiler tube and his explanation, which follows, best explains the action which takes place.

As indicated at A, there are always peculiar spots in boiler plates which are preferred by steam bubbles as the site of their formation. These sites may be caused by a slight reduction in the thickness of the plate, the flaking off of a piece of scale or by a small flaw but these special places always exist.

Bubbles form on a heated plate as indicated, the bubble developing progressively as shown at A. Any magnesium chloride that might be evaporated out of the water in the formation of the bubble would be deposited on the plate and would be dried out under the protection of the bubble. Finally the bubble would escape, and the plate would be wetted again.



MAGNESIUM CHLORIDE DRIED BY THE PROTECTION OF BUBBLE FORMATION CAUSES CORROSION IN STEAM LOCKED BOILER TUBES

During the time that the chloride was dry, it would produce hydrochloric acid, at the temperature of boiling water, which would eat into the plate, the action proceeding as shown at B, in which a crater is formed, surrounded by a heap of the oxide, which was thrown out by the explosion of the bubbles and finally would develop into a pocket with a narrow opening in which the acid is boiled. In this way, the plate ultimately would be eaten entirely through as shown to the right at B.

IN THE ARTICLE entitled Corrosion Affected by Oxygen Content in Water, on page 1255 of the November 1 issue, the values "1 c.c." should have read 0.1 c.c. which changes the statement to read properly, "Oxygen content of 0.1 c.c. per liter or less in boiler feedwater of zero hardness will not cause corrosion." Open heaters are guaranteed to remove oxygen to an amount as low as 0.05 c.c. per liter.

Editorial Comment

What Price Temperature?

Up go temperatures in steam plant practice. Whether pressures of the future shall be 400, 600, 1400, 2800 or 3200 lb., it seems certain that we are to have steam temperatures of 800 deg. or more, with 950 to 1000 deg. the probable top limit. What will it cost in dollars and in risk to use them?

Seemingly the answer rests on the effect of temperature on the creep stress limit. So long as we kept below 600 deg., creep stress figured but little. When temperature goes above 750 deg., its effect on creep stress must be reckoned with. This effect is an insidious thing, as it reaches its maximum result only after a considerable period of service.

In his 1927 report on experience at the Lakeside station, John Anderson showed that, with $\frac{1}{32}$-in. scale and water in the tubes at 575 deg. F., the temperature of the outsides of tubes ran to 711 deg. F. Even with clean tubes, that temperature would be 666 deg., or 91 deg. above water temperature. For the 711 deg., at 1300 lb. pressure, but with no allowance for unequal expansion stress, the stress in tube metal would be 6200 lb. per sq. in., which gave a factor of safety (or of ignorance as some call it) of 2.1.

During long use, at such temperatures, there is an annealing effect which reduces the strength of the tube material, an uncertain factor which can be evaluated only by experiment or extended experience.

At the meeting of the German Association of Boiler Owners last June, it was shown that actual stress may be much higher than that calculated by the usual formulas for stress. For a drum 4 ft. 3 in. diam. at 526 lb., with wall 2¼ in. thick, calculated stress would be 9200 lb. per sq. in. Additional stresses due to expanding the tubes and to temperature effect may increase the total stress to 21,600 lb. at the edges of the holes inside the drum. Stiffness of tubes, uneven expansion and imperfect erection may cause still further increase, bringing total stress close to elastic limit or creep stress limit of safety.

At the outlets of superheaters, steam temperatures up to 968 deg. F. have been found, even when the steam was supplied to prime movers at considerably lower temperature. If the outsides of tubes were only 50 deg. hotter than the steam, this would give 1018 deg. F.

For temperatures up to 930 deg. F., 5 per cent nickel steel has an advantage over mild steel in reduction of creep stress limit: for mild steel, the 9200-lb. limit at 750 deg. drops 75 per cent to 2400 lb. at 930 deg.; for nickel steel, the corresponding drop is from 11,600 lb. at 750 deg., 72 per cent to 3248 lb. at 930 deg. Above 950 deg., a structural change seems to take place in alloys, so that the 5 per cent nickel steel fails to retain its advantage. Spite of these effects, boilers have worked over considerable periods with steam at over 930 deg. and tube material at probably 1110 deg. carrying pressure of 2400 lb. per sq. in. What risk involved is uncertain, but failure, in course of time, is to be expected so that frequent careful inspection and replacement at the first sign of distress would seem to be the only common sense course.

Molybdenum steel appears to have possibilities as its creep stress limit at 750 deg. is double that for nickel steel and seems to decrease more slowly with rise of temperature. Cost of figures for material and working are not yet available but will naturally be higher than for nickel steel. As experience has been gained, cost for 1400 lb. plants has been reduced to but little more than for those for lower pressures. It is possible but not probable that the same will be found true for high temperatures. In any case, we seem to be headed for the use of higher temperatures and, whatever the cost to secure maximum durability and minimum risk, it will probably be a good investment. As for any plant equipment, in the long run, the best will probably prove the cheapest.

Training for Industry

Few men whose duties include the hiring of men for industrial work question the advisability of selecting those who have been trained for the specific duties they shall be asked to perform. In large organizations, arrangements are usually provided for training the novice for special work and much thought is given to determining the vocational qualifications of new employes regardless of the schooling which they may have had. Many of the smaller organizations are built up of men who have secured their industrial training in large companies.

Some employers still have a prejudice against hiring a college man, perhaps, because of previous unfortunate experiences. In the minds of many, however, a college education is a training in fundamentals upon which the special training for the specific duties of the work at hand can be built more rapidly than is possible with non-college men but in seeking employment the college man must expect to take his place by the side of the untrained man and earn his advancement in competition with others through service profitable to his employer.

That college trained men, as a class, are meeting with favorable consideration in the electric utility field was clearly brought out in a report of the N.E.L.A. committee on Coöperation with Educational Institutions which shows that among the employes of the 52 utilities considered, 4¾ per cent of the total were college graduates, the percentage for different companies ranging from 1⅓ to 14. Only one stated that it does not want more college men, because the jobs are not available.

On the basis of their findings, the committee recommended that companies give careful consideration to the advisability of increasing the percentage of college graduates in their employ and that, whenever possible, a definite plan be adopted for accomplishing this.

If utility companies find that training in fundamental subjects, such as is given in colleges to students in engineering and business administration, is an aid in developing their employes, certainly other industries have employe duties that can best be filled by men having college training. The great danger, however, is that employers are likely to expect too much from their new college-trained employes and such employes give too little consideration to the abilities of those whose education has been gained through the school of hard knocks. No matter how high in the scale of formal education a man may go, he is still only partly trained for industrial work. He must prove his ability consistently to make money for his employer, which is the basis upon which every employe should be hired.

Off Duty

News comes to us from Germany that the Junkers Co., whose great all-metal planes travel the air routes between all the important centers of Europe and Southwestern Asia, is building an airplane which will have a speed of 600 miles per hour. This plane is to fly at an altitude of 33,000 ft. (over six miles) where the air resistance is extremely low and where this tremendous speed can be attained with no undue strain on the plane.

Six hundred miles per hour! Think of it as from Chicago to New York in slightly over an hour—an hour and 15 minutes; it seems unbelievable. Yet, coming from Germany, we are inclined to believe the report, for these Germans have shown themselves to be masters of aeronautical design and construction. And we hope they succeed, for despite what we are going to say here, we, too, like most human beings, are strangely fascinated by such feats of speed.

But suppose they succeed—suppose they do make it possible to fly from Berlin to Paris in less than an hour—what of it? Of what particular ultimate benefit will it be to humanity? Will people be any happier because they can go so fast or will the sensation, or rather the thought of the accomplishment give them more enjoyment? After all, what will they do with the few hours saved by this high speed?

Perhaps it is foolish and useless to ask such questions—perhaps we should not look for a reason behind every human action; perhaps the feat of flying 600 miles per hour should in itself be sufficient achievement without our worrying over whether it will be of any use to mankind. In the ultimate analysis, anything we do makes little difference and if man shows himself capable of building a machine which will carry him 600 miles an hour, well, if that's what he likes to do, let him go to it.

Our criticism, if it can be called such, is not of the achievement, but of the silly reasons we are likely to advance in support of these achievements. Today, everything must have a purpose; everything we do, we seek to justify on some grounds or other. Whether it consists in spending several hundred thousands of dollars to enable one man to fly over the South Pole, or whether it concerns the installation of radio telephones on moving trains, everything must be done for a purpose—at least it must have an object noble in purpose. Every politician or bootlegger who finds local conditions growing too hot finds it convenient and not entirely unpleasant to take a trip to Paris or Tahiti, and forthwith embarks on a voyage in the interests of science or art or whatnot. As a matter of fact, the scientific value of many even fairly reputable scientific expeditions is vastly exaggerated. Byrd's enormously costly expedition, if we analyze the facts coldly, was made not to fulfill any scientific need, but primarily to satisfy the spirit of adventure in a small group of men. We are not discouraging polar exploration or, in fact, exploration of any kind; on the contrary, we heartily approve of it, but we do wish that those who engage in it would be more candid as to the reasons underlying their activities.

And so with this question of speed; up to a certain point greater speed is of distinct benefit to humanity. In an early history of Chicago published recently, the hardships of travel in 1840 are recounted vividly. From New York to Chicago then, meant a two or three weeks trip—an arduous, tiresome journey. With the coming of the first railroads around 1850, this time was shortened to two days. This was a decided advance—an achievement of great benefit to humanity, for at one stroke it eliminated all the hardships incident to a two weeks' journey by horse or coach. When this time was cut by faster and more reliable trains, first to one day and later to 20 hours, humanity again was benefited, but not so much as with the first step.

The same is true of ocean travel. Before the days of steamships, when it took from six weeks to two months to cross the Atlantic, a journey to the other side was something more than a mere pleasure jaunt. When the steamship cut this time first to three weeks, later to two weeks and then to nine days, the increase in speed again was of great benefit to humanity. When, however, by great effort and enormous power, the modern ocean greyhounds cut this time to five days, the advantages of this increased speed were less marked.

So it seems that as each increment of speed brings us closer and closer to the ultimate limit, whatever that may be, the absolute value to mankind of these increments decreases. Here, as in other things, the law of diminishing returns holds true. Up to a certain rate of speed, our ability to move faster brings distinct advantages but there is a speed beyond which any further increase does not materially contribute to the welfare of the people as a whole.

For any mode of travel, this limiting speed depends upon the distances it is possible to cover. For a distance of a thousand miles, the difference between 600 miles per hour and 200 miles per hour is not great enough to give the former any great advantage over the latter. On a 6000-mile journey, the 600-mile rate is of considerable advantage, provided it can be maintained continuously over that distance.

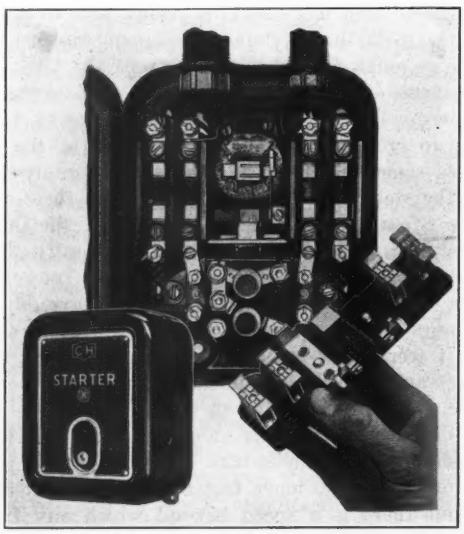
Except in isolated cases, in matters of life and death, the 600 miles per hour plane can offer little that the 100 or 200 miles per hour planes can't give us and while it is interesting to know that man can so attain mastery over space and time, we have a sneaking suspicion that the many claimed advantages of such high velocity transportation are exaggerated.

And so, while we would get a great thrill traveling in a plane at 600 miles per hour and while the designers and builders of such a craft can be justly proud of such an achievement, the achievement itself we can regard only in the light that the realization of it is sufficient unto itself. It needs no justification on the grounds of service.

Power Plant Engineering Developments and News

New Contactor for Cutler-Hammer Motor Control

CUTLER-HAMMER, INC., of Milwaukee, Wis., has redesigned its entire line of type AAA automatic starters for small a.c. motors, to incorporate a newly developed "Twin Break" magnetic contactor. This new contactor provides many features which are of interest.



ACROSS THE LINE TYPE STARTER, USING NEW CONTACTOR. CONTACT BOARD REMOVED TO SHOW SILVER BUTT TYPE CONTACTS

The contacts are of heavy coin-silver which retains its current carrying capacity even if oxidized and always makes a good contact with little temperature rise. The "Twin Break" principle reduces the arc voltage by half and Thermoplax arc pockets, by reducing the air content around the contacts, actually prevent the formation of a destructive arc. These arc pockets also act as a shield so that wires which are run along the side of the contactor cannot interfere with its operation.

A magnetic latch has been added to prevent accidental closure of the contacts if the starter is accidentally bumped or tilted; the latch must be drawn aside by the operating magnet before the contacts can close. This is an important feature, especially if the starter is mounted on moving machinery. A new hinge structure facilitates removing and replacing the contact board and insures correct replacing of the board before the starter can operate.

These new contactors are made in three and four-pole types. The maximum ratings for 2- or 3-phase are: 3 hp., 110 v.; 5 hp., 220 v., and 7½ hp., 440 or 550 v. The illustrations are of the Bul. 9586 across-the-line type starter which is using this new contactor. The contact board is removed to show the silver, butt type contacts.

Live Line Disconnecting Clamp

NEW LIVE LINE disconnecting clamps introduced by the General Electric Co. are for making connections to main conductors from lightning arresters, for apparatus requiring occasional disconnecting, for temporary grounding of transmission lines and for connections during construction work. They are hook-operated and rated 200, 400, and 600 amp.

The clamp is made of copper alloy for use on both copper and aluminum conductors. The contact surfaces of the clamps are given a special finish when the device is used with aluminum conductors. This finish is to reduce the electrolytic action that results when moisture enters an aluminum and copper clamped joint.

Before installing the device, the branch conductor is clamped to the back of the main casting. A switch hook is then inserted in the screw eye and that part is turned until the switch hook is firmly attached to the clamp. The switch hook with the clamp attached is then raised and the clamp is placed over the main conductor. The switch hook is then turned clockwise until the screwbolt holds the conductor firmly in contact with the clamp.

The advantageous feature of the new clamp lies in the fact that it is unnecessary to remove the switch hook

FIG. 1. 200-AMP. DISCONNECTING CLAMP, SHOWN CLAMPED ON SWITCH STICK FOR REMOVAL FROM LINE

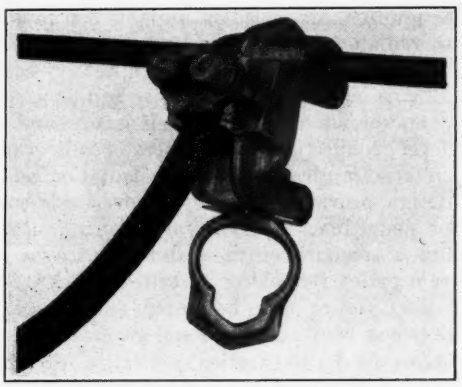


FIG. 2. CLAMP SHOWN IN POSITION ON CONDUCTOR

from the device while attaching the clamp to or removing it from the line. Since the disconnecting clamp is fastened to the switch hook until the clamp is made fast to the main conductor, the device cannot be dropped from the hook and cause damage. The opening in the screw eye is made so that the switch hook can readily be inserted when the disconnecting clamp is mounted on a high structure.

Indicating Pyrometer Controller

MODEL 801 Indicating Pyrometer Controller, recently placed on the market, can be supplied as an automatic control pyrometer, resistance thermometer, tachometer or CO_2 meter. Several advantages are claimed for this instrument. Reading is observed directly on a 6-in. scale.

Index is provided on the scale for setting to exact control point and the design is such that the control point is instantly and easily adjustable.

All wiring terminals and motor are enclosed, to eliminate danger when used in the presence of explosive or inflammable gases.

Mercury switches up to 30 amp. capacity are used to eliminate the necessity of relay equipment. Make and break occurs in sealed glass tube.

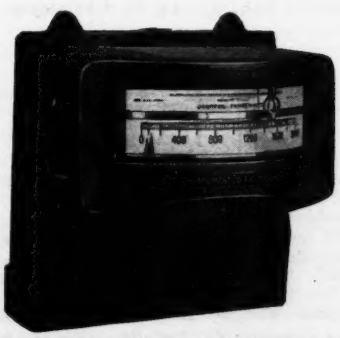
The device is designed to be suitable for "on and off" or "three position" control through switches, valves or dampers.

It is available with patented safety device to open the furnace circuit if thermocouple or wiring fail, to prevent burning out the furnace.

It is designed for resistance to insure accuracy.

Automatic internal compensation is employed to eliminate cold junction errors when the instrument is supplied as a pyrometer.

The control mechanism of Model 801 Indicating Pyrometer Controller is intended to combine the basic principle of the Brown Automatic Control Recorder with the new feature of mercury contacts for breaking high currents. It is a product of the Brown Instrument Co., Philadelphia, Pa.

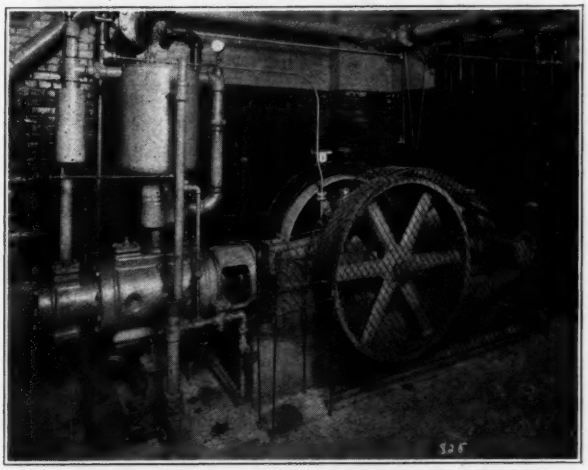


CONTROLLER EMPLOYS MERCURY CONTACTS FOR HIGH CURRENTS

Class 14-A and 15-A Compressors

TWO-STAGE tandem type air compressor, Class 14-A power driven (Class 15-A steam driven), for pressures up to 250 lb. per square inch has recently been designed for the purpose of providing a compressor which, within the range of its capacity, would meet all the requirements of two-stage tandem service and which at the same time would be more economical of floor space than the standard two-stage tandem type.

The feature of this compressor is that the high-pressure cylinder is single acting, instead of double acting, as in standard construction; this high-pressure cylinder is attached directly to the low-pressure cylinder without any distance piece between the two cylinders. A plunger at the end of the piston is provided to act as the piston for the high-pressure cylinder and to compress the air in this cylinder at only one stroke of the piston rod. This construction, when combined with the overhead type of motor mounting for multiple belt drive, is intended to make a compact unit. The new type compressor has just been placed on the market by Pennsylvania Pump & Compressor Co., Easton, Pa.



CLASS 14-A, 8 AND 5 BY 8-IN. HYDROGEN COMPRESSOR

Gear Lubricants

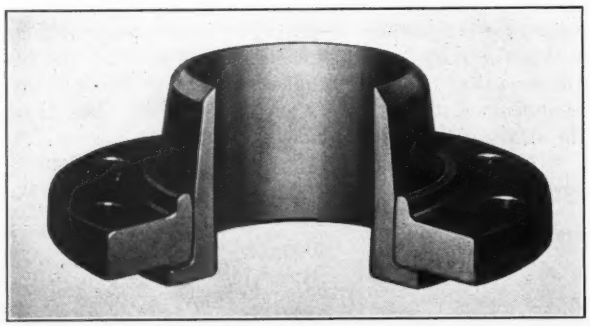
NEW SERIES of gear lubricants designed for all types of heavy, slow-moving, open gears has been developed by the Research Staff of E. F. Houghton & Co., Philadelphia, Pa. These are known as Tenac No. 1, No. 2, No. 3 and No. 4.

This staff has developed a lubricant which, it states, will not be thrown off the gears while they are in motion. It is stated that "Tenac has been tried in practically every type of gear installation and under most adverse conditions. In every case it has met all requirements successfully."

Tenac No. 1 is the heaviest of the series, while Tenac No. 4 is the lightest grade. One advantage claimed for the Tenac series is its extremely low cold test. No special device or method of application is required with the use of the Tenac series of gear lubricants.

Swivel Flange for Welded Pipe

FLANGED JOINT, developed for use in connection with welded pipe lines is known as the Merco swivel flange and is designed to possess the inherent flexibility of the Vanstone type of flange, plus the strength of an



FLANGE ROTATES ON TAPERED NIPPLE

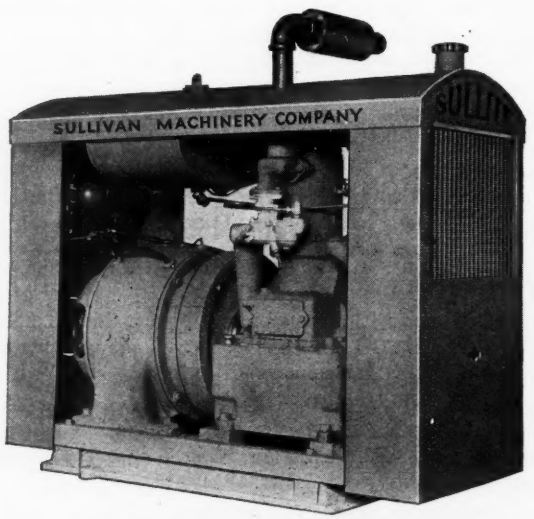
ordinary butt welded flange, according to the manufacturer. It consists of a drop forged steel flange, fitted to a drop forge tapered nipple on which the flange may be rotated, permitting alinement of bolts. The tapered nipple is forged from a solid steel billet and the finished product incorporates a thickness much greater than pipe at the base of the nipple where highest stress occurs. The manufacturer states that by forging from a solid billet sufficient heat is stored up in the steel to permit operation being finished at the correct forging temperature.

The manufacturer, Merco Nordstrom Valve Co., San Francisco, Cal., is arranging production to make available sizes from 1½ to 10 in. and specifications are to meet the American standards in strength requirements. Where service requires a special alloy such as the new chrome nickel steels, the tapered nipple only is forged from the alloy, while the flange is forged from ordinary steel, to permit a less costly flanged joint. The tongue and groove type of construction can also be incorporated when desired. These flanges can be furnished with pipe nipples of various lengths welded on before leaving the factory.

Sullite Electric Generating Plants

FOR CONSTRUCTION work and other jobs where power and light are needed temporarily and electric supply lines are lacking, these self-contained plants, made by the Sullivan Machinery Co. are available. The unit includes a 1-cylinder, 4-cycle gasoline engine with magnetic ignition, air-cooled in units of 350 to 1500 w. and with radiator for water cooling in 1500 to 2500-w. units. Voltage is 110 standard but a battery-charging set for 12 v. is made in the 400-w. size and 32-v. sets are supplied on special order. Starting is by hand crank or foot lever; connection to the generator is by a plug-in socket; interpoles give sparkless commutation and generator design provides for carrying overloads continuously for some time. Sheet metal housing can be provided and is standard on the water-cooled sizes, which also have a pulley for taking off belted power. For the smaller sizes, power may be belted from the spring-coupling casing between engine and generator.

As shown in the illustration, the larger sizes have a panel with main switch fuse block and field rheostat mounted at the generator end but, as in smaller sizes, generators are compound wound so that voltage regulation with change of load is automatic. Gasoline consumption of 1¾ pt. per kw-hr. is reported.



SELF-CONTAINED GENERATING PLANT

For larger requirements, 4-cylinder plants of 1½ to 15 kw. are supplied at 110 or 220 v., d.c. and in sizes 1½ to 10 kv-a. at 110 v., a.c. They are water-cooled with radiators and have panel switchboard mounted on top of the generator.

CHRISTMAS SEALS in aid of the fight against tuberculosis will this year be as shown in three colors. The sale runs from Thanksgiving to Christmas and all re-

ceipts for seals will be invested in protection of the health of the community, by education, nursing for the sick, medical advice and fresh air camps for children.

News Notes

ERECTION OF A new $185,000 factory building at the Northwestern Terminal for the Strong-Scott Manufacturing Co., Minneapolis, Minn., will start immediately, A. W. Strong, president, has announced. The plant will cover a half block facing Taft street and will be between Traffic and Kennedy streets. With the building itself costing $185,000, the land valued at $40,000 and the equipment for the building $125,000, the factory, when completed, will represent a value of $350,000.

"We could manage in our present quarters for a number of years, but since we had had a new plant in mind for some time, we felt that, with the city faced with an unemployment problem, now was the time to build and do what we could toward furnishing employment to as many people as possible," Mr. Strong said in announcing plans for the new building. He said the company hoped to be in the new plant by Feb. 1, 1931.

EARLE S. HENNINGSEN has been appointed engineer of the alternating current engineering department of the General Electric Co., succeeding H. G. Reist who has retired.

W. D. CAMERON has been appointed manager of the Detroit office of the General Electric Co., to succeed the late J. H. Livsey, it has been announced by W. O. Batchelder, manager of the central district. Since 1927 Mr. Cameron had been assistant manager of the Detroit office.

UNITED STATES Employment Service has opened an office in Room 538, 608 S. Dearborn St., Chicago, Ill., in charge of Thomas W. Creighton, to secure employment for ex-service men. Mr. Creighton requests employers to file requisitions for help with him and promises every possible effort to meet requirements.

MERGER of the Carrier Engineering Corp. of Newark, N. J., the Brunswick-Kroeschell Co. of New Brunswick, N. J., and Chicago, and the York Heating and Ventilating Corp. of Philadelphia, each one of the largest concerns respectively in the air conditioning, refrigerating and unit heating and ventilating industries has just been announced. Including subsidiary and affiliated concerns, the merger will unite fifteen companies, five of them foreign, with total assets of approximately $15,000,000.

"The consolidation will provide a single world-wide organization equipped to provide any desired kind of indoor atmospheric conditions in homes, hotels and apartment houses, stores, theaters, office buildings and industrial plants," J. I. Lyle, executive vice-president of the Carrier Corp., stated in making the announcement. "The merger plan contemplates that the fifteen companies involved will retain separate entities under a holding company to be known as the Carrier Corp., which will conduct all research and will direct sales and engineering activities for the group."

William Piez, European correspondent of Link-Belt Co. and a brother of Charles Piez, Chairman of the Board, Link-Belt Co., died at Brussels, Belgium, on November 2 after a week's illness. Previous to his latest association, Mr. Piez was district manager of the Concrete Steel Co., Chicago. Since 1928 he has lived at Paris, France, where he functioned as European correspondent of Link-Belt Co. He was born at Newark, N. J., in 1878.

FEDERAL PRESSED STEEL CORP., Milwaukee, Wis., is having plans and specifications prepared for a new power plant. Initial installation will consist of stoker-fired high-pressure boilers; ultimately electrical generating equipment will be added. Ottomar H. Henschel, 401 Commerce Building, Milwaukee, Wis., is consulting engineer.

AS A CONTRIBUTION toward hastening return to normal business conditions and to counteract the tendency prevalent during periods of restricted business, Directors of the Peabody Engineering Corp. have declared a special dividend of $15 a share, payable immediately to holders of common stock and have established a fund not to exceed $7 a share to be distributed at once to employes in place of the usual bonus and profit sharing paid during the Christmas holidays. The thought has been to put money in circulation now, thus helping to overcome the psychological tendency to restrict expenditures and slow down business.

HARBISON-WALKER REFRACTORIES Co. has just completed a 5000-ft. motion picture illustrating modern methods employed in the manufacture of refractories. The film shows every step in the production of refractories from the mining of raw materials to the loading and shipping of the finished product. Scenes in the research and control laboratories and some interesting animated photography showing the action of periodic and continuous tunnel kilns are also included in the picture. This Harbison-Walker film is available, without cost, to technical societies, engineering organizations, industrial organizations, universities, colleges, technical schools and research laboratories. Further information about it can be obtained from Harbison-Walker Refractories Co., 1800 Farmers Bank Building, Pittsburgh, Pa.

LINK-BELT Co., Philadelphia, Pa., announces the appointment of Frank W. Lovett as engineer in charge of sewage disposal equipment in the Western territory, to be located at 300 West Pershing Road, Chicago. His services, with 8 yr. experience in the designing of machinery for sewage treatment plants are available to municipal and industrial sewage disposal plant engineers and managers.

MARK ANDERSON, for 11 yr. manager of the Ft. Dodge (Ia.) Gas & Electric Co., has been transferred to Cedar Rapids as general manager of the Cedar Rapids branch of the United Light & Power Co., parent organization of the Ft. Dodge and Cedar Rapids utilities. Mr. Anderson succeeds Hiram J. Carson, who has been made vice-president of the Northern Natural Gas Co. in Chicago, in which the United Light has large interest. The Ft. Dodge plant is undergoing expansion which will double its productive capacity. T. C. Roderick, for four years manager of the corporation's gas company in Ottumwa, will succeed Mr. Anderson in Ft. Dodge. Changes become effective at once.

C. F. MESSINGER, vice-president of the Chain Belt Co., Milwaukee, Wis., has been elected general manager. H. S. Greene, formerly with the Barber-Greene Co., of Aurora, Illinois, who joined the Chain Belt Co. in 1929, succeeds Mr. Messinger as general sales manager. Brinton Welser, formerly secretary, was elected director and vice-president. J. C. Merwin was re-elected as vice-president. A. R. Abelt was elected secretary of the company and continues in charge of chain sales. W. H. Brandt, formerly assistant secretary, becomes assistant to the president.

FRANCIS L. SEARWAY has joined the Stone & Webster Engineering Corp., Boston office, as engineer in the appraisal division. Previous to this connection Mr. Searway was associated as appraisal engineer with Shell Eastern Petroleum Products Co., Forstall Robinson & Luqueer and Lockwood, Greene & Co.

W. S. ANDERSON, JR., has been appointed sales engineer for The Bigelow Co., New Haven, Conn., effective November 1 and will have charge of the Boston office.

J. H. WILLIAMS & Co. has just closed contracts for an addition to its plant at Buffalo, N. Y. The extension will provide an increase of approximately 30,000 sq. ft. in floor space, to be used for additional heat-treating facilities and also for finishing, assembling and storing the company's standard stock products.

AMERICAN CANDY Co., Milwaukee, Wis., is about to rehabilitate the electrical and mechanical equipment in its power plant and manufacturing plant. Ottomar H. Henschel, 401 Commerce Building, Milwaukee, Wis., is consulting engineer.

Books and Catalogs

SULLITE electric lighting plants for illumination of jobs that must be carried on at night time, when electric light is not available from the usual sources are described and full information concerning the sizes of units available, and details of their service are given in Bulletin No. 100-B issued by the Sullivan Machinery Co., 400 No. Michigan Ave., Chicago, Ill.

APEXIOR coatings, applied like paint for preservation and protection of metal surfaces, are described in the new Bulletin No. 1238 issued by Dampney Co. of America, Hyde Park, Boston, Mass. Illustrations show types of boilers in which such coatings are used, how to apply them together with a short description. A section is devoted to condensers and other cold wet applications below 125 deg. F., also to hot, dry surfaces up to 450 deg. F. Equipment for application of Apexior coatings for prevention of corrosion in boilers, economizers, condensers and the like is described and illustrated in Bulletin 1234 issued by The Dampney Co. of America. These devices are for applying the coating by brush or wiping action to the surfaces of drums, of water walls and of straight or bent tubes from 1½ to 4 in. diameter.

SELECTION of elementary information that is needed by every fireman is contained in a booklet entitled Questions and Answers for the Coal Fireman, by J. F. Barkley, just published by the United States Bureau of Mines, Department of Commerce. The booklet is written in easily understandable language and is intended to give the fireman a clear, concise idea of just what happens when coal is burned under a boiler furnace and of the best methods of firing to avoid waste and smoke. In size it is adapted to the pocket and it has a flexible cloth cover to withstand frequent handling.

BUYERS GUIDE, Fall issue for 1930, sent out by the International Nickel Co., Inc., 67 Wall St., New York City, gives a directory of manufacturers, fabricators and distributors of nickel alloy sheet products, classified according to product. Classifications have been simplified and new items added, also size limitations and minimum requirements for an order are given.

Power Plant Construction News

Ala., Anniston—The Acme Weaving Co., Anniston, plans installation of electric power equipment in proposed addition to textile mill, entire project estimated to cost about $80,000.

Ark., Fort Smith—Banfield Brothers, Tulsa, Okla., plan installation of electric power equipment in proposed new meat packing plant at Fort Smith, entire project reported to cost about $75,000. A boiler house is projected.

Calif., Fresno—The Fresno Consumers Ice Co., Mono Street, has approved plans for extensions and improvements in ice-manufacturing plant at Mono and P Streets, to cost about $35,000.

Calif., Los Angeles—Multicolor, Ltd., 7020 Romaine Street, plans installation of electric power equipment in proposed addition to motion picture film laboratory, entire project to cost about $85,000.

Calif., Los Angeles—The Philadelphia Quartz Co., Sixth and Grayson Streets, Berkeley, Calif., plans installation of electric power equipment in proposed new chemical plant at South Gate, Los Angeles, entire project to cost over $200,000.

Calif., Martinez—The Associated Oil Co., 79 New Montgomery Street, San Francisco, is said to be planning the construction of a power plant in connection with expansion and betterment program at Avon refinery, near Martinez, recently referred to in these columns, entire project to cost about $1,500,000. Company engineering department is in charge.

Ga., Augusta—The Atlantic Ice & Coal Co., 106 Washington Street Viaduct, Atlanta, is said to be planning the construction of an ice-manufacturing plant at Augusta, to cost about $45,000, with equipment. A similar plant is proposed at Macon, Ga., to cost a like sum.

Ga., Dry Branch—The Superior Mineral Products Co., Somerset, Pa., Martin L. Markell, president, plans installation of electric power equipment in proposed new clay-washing and refining plant on tract of land, recently acquired at Dry Branch, entire project to cost close to $150,000.

Ill., Belleville—The New National Coal Co., Belleville, is said to be planning rebuilding of power house at coal mining properties, near the city, recently destroyed by fire with loss approximating $30,000.

Ill., Chicago—The Pullman Co., 79 East Adams Street, plans installation of electric power equipment in proposed new laundry plant at 3333 West Forty-third Street, entire project reported to cost more than $300,000.

Ind., Rockville—The Board of Trustees, Indiana State Sanatorium, is considering the construction of a steam power plant in connection with an expansion and improvement program at institution, to cost about $57,000, with equipment. Entire program will cost more than $1,000,000. A sewerage disposal system will be installed.

Kans., Kansas City—The Board of Public Utilities, Kansas City, plans installation of pumping machinery and power equipment in connection with proposed extensions and improvements in Quindaro waterworks station, entire project reported to cost over $500,000. The Burns & McDonnell Engineering Co., Interstate Building, Kansas City, Mo., is engineer.

Kans., Wichita—The Steffen's Ice & Ice Cream Co., First National Bank Building, plans installation of electric power equipment and refrigerating machinery, etc., in connection with a new two-story and basement plant, 90 x 200 ft., estimated to cost close to $175,000.

Ky., Paris—A bond issue of $150,000, has been approved by local citizens for a municipal electric light and power plant, and City Council is said to be arranging to have plans drawn at an early date.

Ky., Walton—The Town Council is reported planning installation of pumping machinery and auxiliary equipment in connection with a water works system to cost about $25,000.

La., Crowley—The Louisiana Public Utilities Co., Lafayette, is considering the construction of a one-story ice and cold storage plant at Crowley, to cost about $50,000, with machinery.

La., New Orleans—The Municipal Sewage and Water Board, 526 Carondelet Street, is said to have plans maturing for a one-story pumping station, 50 x 115 ft., on Orleans Street, to cost over $100,000, with equipment.

Mass., Fitchburg—Crocker, Burbank & Co., Fitchburg, have plans under way for an addition to power plant at local paper mill, reported to cost about $45,000. F. J. Sill, East Main Street, Westboro, Mass., is engineer.

Neb., Orleans—The Western Public Service Co., Scottsbluff, Neb., will proceed with the construction of an electric light and power plant at Orleans, to cost about $100,000, with equipment. Company also plans the installation of a high-tension transmission line from Orleans to Holdrege, Neb., to cost about $35,000.

N. B., Minto—The New Brunswick Electric Power Co., Canterbury Street, St. John, N. B., has approved plans for a one-story steam-operated electric power plant at Minto, reported to cost approximately $65,000, with equipment.

N. H., Freemans Point—The Atlantic Gypsum Co., is said to be planning the installation of electric power equipment in connection with proposed rebuilding of portion of local mill recently destroyed by fire with loss reported at close to $100,000.

N. J., Newfield—Robert Cleeland's Sons, Inc., 1121-31 Waverly Street, Philadelphia, Pa., plans rebuilding of power plant and portion of textile mill at Newfield, recently destroyed by fire with loss reported in excess of $65,000.

N. Y., S. I., Port Ivory—The Procter & Gamble Co., Port Ivory, has plans for a one-story addition to boiler plant at local soap works, 35 x 70 ft., reported to cost about $35,000, with equipment.

Ohio, Canton—United Engineering & Foundry Co., Farmers Bank Building, Pittsburgh, Pa., plans installation of electric power equipment in connection with an expansion and improvement program at rolling mill machinery-manufacturing plant at Canton, entire project to cost over $200,000.

Ohio, Cincinnati—The Hauser-Stander Hank Co., Spring Grove Avenue, plans installation of electric power equipment in proposed new plant addition to cost over $125,000. Lockwood, Greene Engineers, Inc., Hanna Building, Cleveland, Ohio, is architect and engineer.

Okla., Tulsa—The Grand Hydro Electric Co., Tulsa, W. E. Hudson, Sixth and Peoria Streets, president, is said to have plans maturing for proposed hydroelectric power project on the Grand River, near Pryor, entire project to cost over $10,000,000, with transmission lines.

Pa., Hatfield—The Borough Council has plans under way for a municipal electric light and power plant, reported to cost over $40,000, with equipment, and will soon ask bids. S. W. Franklin, Lansdale, Pa., is engineer.

Pa., Johnstown—The Bethlehem Steel Co., South Bethlehem, plans installation of electric power equipment in connection with an expansion and improvement program at its Cambria works at Johnstown, entire project to cost more than $2,000,000.

Texas, Houston—The Saline Chemical Co., Houston, recently organized by W. S. Hipp, Houston, and associates plans installation of electric power equipment in proposed new chemical plant at Pierce Junction, near Houston, entire project reported to cost more than $500,000.

Texas, Temple—The Southland Ice Co., Dallas, Texas, plans extensions and improvements in ice-manufacturing plant at Temple, reported to cost over $30,000.

W. Va., Charleston—The Electro Metallurgical Co., 30 East Forty-second Street, New York, a subsidiary of the Union Carbide & Carbon Co., same address, plans installation of electric power equipment in connection with an expansion and improvement program at plant at Charleston, entire project reported to cost more than $1,000,000.

Wis., Two Rivers—The City Council has engaged the Burns & McDonnell Engineering Co., Interstate Building, Kansas City, Mo., to make surveys and prepare plans for a proposed municipal electric light and power plant, entire project to cost close to $100,000. E. J. Donnelly is city manager.